Editorials

Elmer L. Corthell

Probably no member of the American engineering profession had a wider acquaintance than Elmer L. Corthell, whose death, on May 16, was announced in our last issue. Yet the most important engineering works on which his claim to professional distinction rested were carried out 25 to 50 years ago. His intimate friends will recall that a score of years or more ago Mr. Corthell had a severe and long-continued illness, which robbed him of the sight of one eye. His restoration to health was very slow, and his retirement from the active practice of his profession may be said to date from that time. Although he received afterward a few notable commissions, such as membership on the Advisory Board of the New York Barge Canal, his days as an active force in the construction world were over.

Most engineers who step out or are crowded out from professional work after they have achieved important positions and distinction find that the busy world soon forgets their existence, save a few old-time personal friends; but Mr. Corthell was without doubt far more widely known at his death than when at the summit of his active professional career as a construction engineer he built the West Shore R.R. in 1884.

His recent election to the Presidency of the American Society of Civil Engineers was of course an important reason for this; but that office, like the offices he held in other engineering societies, came to him because of the services he had rendered to the profession in connection with its organizations, and the distinction he had gained thereby.

All his life long, but especially when he found himself with spare time on his hands after his long illness, Mr. Corthell was ready to devote himself to the work of engineering organizations, with the single-hearted purpose of benefiting the profession. At the time he gave his library to Brown University, a few years ago, Mr. Corthell was a member of 25 engineering societies and congresses, American, foreign, and international. And membership with him invariably meant work. He did not become a member of a society to see what he could get out of it for himself, but to give to it whatever service he was able in its work for the profession.

Particularly was he interested in the international congresses of engineers which have played such a great part in the past twenty years in promoting the solidarity of the profession, although now unfortunately interrupted by war. Mr. Corthell's prominence in the International Railway Congress, the International Navigation Congress, the Pan-American Scientific, and others, with his long residence and extensive work in foreign lands, made his name better known abroad probably than that of any American civil engineer of the present day except General Goethals. The profession needs more men like Corthell, willing to devote spare energies in their declining years to work for the general welfare. They will find, as he found, that such work is well worth the doing.

Selecting Hydraulic Turbines

Great advance in American turbine and hydraulic power-station designing has been made since engineers on this side of the Atlantic began to use the concepts of "type characteristic" and related ideas. The peculiar advantage of the "type characteristic" as a criterion of turbine design lies in its simultaneously measuring the difference between various designs of runners, and combining the controlling hydraulic conditions (speed, power and head) of a given site into a single factor which indicates what sort of a wheel is best suited. The development of efficiency-contour diagrams (iso-efficiency lines on a field having speed and power coördinates), which have come into use in this country along with the idea of type characteristic, has been a second great aid in promoting the study of turbine runners by showing on a single sheet, as it does, the efficiencies which can be secured from a given machine at all speeds and outputs within its working range.

It has remained for Messrs. Horton and Pomeroy (as is shown elsewhere in this issue) to connect up type-characteristic and efficiency-power-speed studies, and thereby to simplify and promote to a much greater extent than heretofore possible the studies of turbine design which must precede an intelligent selection of equipment. They have approached this desirable end first by making the speed and power coördinates for their isograms proportionate quantities rather than absolute—referring as unity to speed and power for maximum efficiency. Now by mentally reducing the dimensions of the runner under study until the absolute value of power becomes unity under 1-ft. head, the corresponding best-efficiency speed is the type characteristic. This makes the proportionate-scale isogram apply to all the homologous runners having this type characteristic—it enables making almost at a glance the fundamental comparison (neglecting of course those inevitable minor differences between homologous runners of different and even of the same size). By introducing two constants, one the diameter of the hypothetical type runner which develops 1 hp. under 1-ft. head, and the other the product of diameter and speed of this runner, it is possible quickly to compute the diameter of a given type of runner which will give the required capacity and speed at best efficiency.

The authors have naturally confined themselves solely to a discussion of their system of turbine study, but attention should be called to the tests of one of the turbine runners, cited by them as an example for applying the new studies. The runner designated as "Holyoke Test 2267" was designed by Mr. Pomeroy in an effort to secure for industrial mills a machine of maximum flexibility—a wide range of speed at nearly constant efficiency, and high efficiency with constant speeds over a wide range of head. Knowing that the ways in which these ends are reached are generally considered incompatible with securing the very highest attainable efficiency, the

performance of this runner is really remarkable. Its maximum efficiency is 88.86%, under 25-ft. head and 220 r.p.m., a figure which compares with the best record of any type of turbine—93.07% for the Leffel runner designated as Holyoke Test 2359. For 20-ft. head the constant-speed efficiency is 87.3%; for 36-ft. head it is 85%. For full gate the capacity runs from 210 to 515 hp. So far as has yet been demonstrated, this design gives the highest efficiencies over the widest range of any runner yet built.

Aside from the obvious economy of having such a runner in a one-unit mill where the load is not constant (and there are a few engineers for hydro-electric operating companies who believe that well sustained efficiency is always more important than a high peak no matter how good the load factor) such a flexible design is well adapted for service where overload capacity is needed. Few men and too few engineers realize that a hydraulic turbine can have overload capacity—thinking perhaps that a good turbine necessarily has to be operated at full gate for normal power. "Full-gate" today is somewhat of an arbitrary position and there can be a wider opening than required for maximum efficiency and normal capacity, the added power at higher openings being the overload capacity. Up to now serious computations of performance of a turbine selected for large overload capacity have been attempted only by a few specialists. Now power to do this is at any engineer's disposal, as illustrated in the Horton-Pomeroy article, and better still overload performance is visualized in the diagrams presented.

Drastic Sewage-Disposal Law

Texas would be a rich field for engineers, contractors and supplymen this year if its State Board of Health were to undertake and succeed in the literal enforcement of the drastic anti-stream-pollution law printed elsewhere in this issue. The sweeping provisions of the law apparently contemplate that all sewage in Texas, except on tidal streams, must be treated to a high degree by Jan. 1, 1917. Failure to see that this is done renders individuals, directors of corporations and members of municipal governing bodies liable to cumulative fines, injunction and, if the injunction be not obeyed, then to punishment for contempt of court.

On the face of the statute there is little chance to escape from the mandatory provisions of the law to cease polluting water used for "farm, live-stock, drinking and domestic purposes." The only hope of warding off the necessity of treating all sewage so as to bring it to a drinking-water standard is (1) the chance for litigation over the meaning of "pollution" and over the reasonableness of the act and (2) that the enforcement of the law is left to the State Board of Health, which obviously must exercise discretion in its efforts at enforcement—all the more so because the law provides for only a single inspector of pollution. There is evidence that the board and its sanitary engineer are going slow in the enforcement of the law, but it seems to be a serious error to pass legislation so drastic that those responsible for its enforcement virtually have to suspend it entirely as regards many cities and largely as regards all.

Since so much discretion must be used in violation of the law, how much better it would have been to have given the board explicit power to compel the construction of sewage-treatment works wherever their necessity is dictated by the interests of public health or the prevention of public nuisance, the character of each plant and its efficient operation to be within the control of the board. At the same time the board—if it now lacks it, as is likely—should have been charged with the far more important power and duty of seeing that every municipality or company in the state supplying water furnishes nothing but water that is hygienically safe.

Doubtless many Texas cities will, spurred on by the law in question, establish some sort of sewage-treatment works—and operate them shiftlessly—when the same money might be better spent for some public works or service having a far more direct bearing upon public health.

The Texas Stream-Pollution Act is commendable in that it shows a desire to protect the public health. It is unfortunate through betraying an ignorance of the fundamentals of sanitary science and sound public policy—and of knowing how to make a dollar contribute most to the protection of life and health.

Light on Flat-Slab and Other Concrete Floor Tests

While on the face of the returns the most important feature of the extensive concrete floor tests at Seattle, noted on another page, is the superior residual strength of the girder and slab floor as compared with the flat-slab, or at least a greater margin of safety in the former under current design methods, one should not overlook the less obtrusive but equally important excuses for the potential failure of the mushroom floor.

One of these excuses, the claim that the slab did not set up on account of cold weather, is not sufficiently answered in the report. The four-way slab was poured in December and tested in April, and the mean temperature of the period was about 45° F. The other two floors were made and tested in warm weather. Concrete 113 days old may reach a fair proportion of its final strength under such conditions, but the burden of proof is on those who claim that it does and in the report the testers show no figures proving the integrity of the concrete itself. Concrete cylinders cut from the floors approximate the strength of those cast separately, but data as to the time of cutting or manner of storage in curing are not given.

In this first excuse the designer of the floor has the better of the argument, unless more is known of the concrete than appears in the report. Had such a building collapsed, can one doubt that the investigators would have brought up the time-worn cry of frozen concrete?

The second excuse is that the steel was grievously misplaced in construction, and unexpected loads thereby thrown on the steel and concrete. This is a most unfortunate argument to be made by one engaged in the commercial promotion of concrete buildings. If this system of design is so delicate that construction errors made by skilled if not expert workmen, foremen, and engineers, honestly endeavoring to follow design, can cut in half a computed strength, the design is obviously not proper for engineering construction.

Entirely aside from these criticisms, the Seattle tests contain much that should interest the Joint Committee

which is now laboring on the flat-slab problem. The four-way test confirms some generally held doubts as to certain mathematical gymnastics; the two-way test, while certifying the main points of its design, emphasizes the dangers of wall column eccentricity, and the beam-and-girder test, as Mr. Hooker so well points out, shows how much of the strength of such structures is due to factors not considered in design.

Higher Pay and Shorter Hours

For many years the eight-hour day has been the slogan of leaders in the labor movement. They succeeded years ago in establishing the eight-hour day in nearly all Federal Government, state, and municipal work, but, up to a year ago, they have had little success in securing the adoption of the eight-hour day in industries carried on by private enterprise. The enormous demand for labor during the past year, however, and the cutting off of the supply of immigrant labor from Europe have given the labor leaders their long desired opportunity. More progress has been made in securing the eight-hour day in the past year than in the preceding quarter century.

In the machinery trade, it is stated by a writer in the *Survey*, that whereas on Jan. 1, 1915, only 7,000 members of the International Association of Machinists were working eight hours, on Jan. 1, 1916, no less than 60,000 were working eight hours. In the shops of Springfield and in Bridgeport, two of the most important centers of machinery manufacture in New England, the eight-hour day has been adopted during the past year. If it continues there, Worcester and Providence will have to follow the example or lose many of their best workmen.

In the anthracite mining industry an agreement reached on Apr. 29, between the leaders of the United Mine Workers and the coal operators, establishes the eight-hour day for 110,000 workers in the anthracite coal fields, with an increase in wages amounting, according to the claims of President White of the United Mine Workers, to at least $10,000,000 per annum.

The burden of this wage increase to the miners is to be borne by the consumers, with something added, apparently, for good measure! The Philadelphia & Reading Coal and Iron Co. on May 9 announced advances in the wholesale prices of coal amounting to 40c. per ton for stove, 50c. for pea, 15c. for egg, 20c. for chestnut, and 20c. for buckwheat. If President White's claim is correct that the advance in wages in the anthracite fields will amount to $10,000,000 and the annual production of anthracite is assumed at 80,000,000 tons, it would appear that an average increase of 12½c. per ton in the selling price of coal would be a sufficient advance to transfer the wage increase to the consumer. Coincident with the announcement of the advancement in price, there came a statement that the Attorney General of the United States has requested the Fedral Trade Commission to make an investigation and determine whether the increase in coal prices is warranted.

It should be noted that by no means all the efforts to secure the eight-hour day are successful. A notable illustration to the contrary is the recent strike in the Westinghouse Electric Co., where the employees returned to work on May 8 as a result of the announcement by President Herr that all those participating further in the strike would be excluded from the company's pension and benefit system. A factor in the ending of the strike was doubtless the very high wages which many of the piece workers on munition production have been making, and which they were not anxious to reduce by the adoption of the eight-hour day.

The most important of all the demands for an eight-hour day is that made by the railway trainmen of the United States numbering over 400,000. Their demand is that the daily wage rate shall remain as at present and that time and a half shall be paid for all time over eight hours. Representatives of the trainmen's brotherhoods and of the railway companies are soon to meet in joint conference in New York City and endeavor to reach a basis of agreement. The *Commercial and Financial Chronicle* of New York, in a recent review of the situation, declares that the railway companies by yielding to the employees' demand that the railways shall deal with the employees collectively, instead of a company dealing with its own employees, have practically surrendered to the trainmen in advance. It says:

> The railroads have delivered themselves bound hand and foot into the control of these labor organizations. Disagreement now means inevitably a general strike and a complete suspension of transportation facilities. That would be a catastrophe of such frightful dimensions and such paralyzing effect that the railroads could not afford to let it occur and the public would most decidedly not allow it to occur.

An estimate has been published that the cost to the railways of the United States of granting the demands of the trainmen will be $100,000,000 a year. There are some 300,000 employees in freight train service who would be affected by such a change to the extent of adding 50% to their hourly wages every day after they had worked eight hours. It is obvious that without a wholesale change in division points and length of runs, which it would take years to accomplish, it will be impossible for the railways to materially change the length of working day of freight trainmen. In 1914 the average daily earnings of enginemen were $5.27; of firemen, $3.24; of conductors, $4.49; of other trainmen, $3.10. A rough estimate based on these figures shows that the estimate of $100,000,000 above noted is not extravagant.

It will be impossible to grant such high rates of compensation and short working days for trainmen without doing something for other classes of railway employees whose wages are at present much below those paid to trainmen for equal service and responsibility. The average wage of railway trackmen for example is only $1.59, taking the average of the whole country, and section foremen receive only $2.21. Within the past year the demand for ordinary labor for work on contract jobs, on farms, in mines and in factories have compelled the railways in many parts of the country to raise the wages of section men in order to hold their forces.

It is of interest in this connection to note that the entire net earnings of all the railways of the United States in 1914 available for the payment of dividends and for improvements and extensions was only $287,000,000 in round numbers. The payment of $100,000,000 in increased wages to trainmen, therefore, would require over one-third of the present profits of the railway companies. If such a reduction in railway earnings takes place, it will most seriously handicap the railway companies in obtaining new capital. On the other hand the congestion of traffic of the past few months has demon-

strated how essential it is that railway credit shall be maintained so that the railways may be able to make the further large investments necessary to increase their capacity. The probabilities are, therefore, that the trainmen's demands will be granted and the public will have to pay the bill in an increase in railway rates.

There is no room for doubt that public opinion holds a very different attitude toward the eight-hour work day from that which was held a quarter-century ago. One finds many men nowadays not alone among workmen and their leaders, but among the leaders in professional and business life and those directly in charge of labor who declare that under modern factory production with high speed machinery and its requirements, 8 hours' work in 24 is as long a working day as the average man can endure without early breakdown. Many firms engaged in industries where profits are large have voluntarily established the eight-hour day. Examples are the Ford Motor Co., the Remington Typewriter Co., the Victor Talking Machine Co. On the other hand, in a strictly competitive industry it is practically impossible for one firm to establish the eight-hour day if competing concerns equally well equipped and well managed are working ten hours. The establishment of the eight-hour day, therefore, in such industries is dependent on the existence of a labor union strong enough to control operations in the entire industry, so that all competing firms have to purchase their labor on the same basis.

There are other industries, however, where the work is dependent on the weather or the seasons, in which no defense of the eight-hour day can be made and no demand exists for its establishment. The farmer must work long hours when it is time to plant and gather his crops, or suffer heavy loss; and he can take his rest at slack seasons and on rainy days. There is a great deal of construction work, such as spreading bituminous oils in road construction, for example, which can be done only in favorable weather, where the limitations of an eight-hour day may constitute a real hardship to the industry and to the workers.

That the general extension of the eight-hour work day will have far reaching effects goes without saying. The first and most obvious effect is an increase in the cost of living. Higher prices for coal, higher rates for transportation, higher taxes because of the eight-hour workers in government employ are typical of the result in all industries. Of course, in any industry where work is so intense that a man can produce as much in an eight-hour day as in a ten-hour day there will be no increase in production costs.

The real test of the eight-hour day will come when it meets international competition. The United States must hold its foreign markets to keep its factories busy and its workmen employed. Sooner or later it must sell its goods again in competition with the factories of Europe. The puzzle is to know what condition these foreign competitors will be in after the war. Were they as well equipped as they were two years ago, the United States would have little chance in the competition except in certain lines where it has great natural advantage.

Certain conditions will handicap the foreign manufacturer after the war. Labor will be scarce and production of all sorts will be under the heavy handicap of enormous taxation made necessary by the war debts. On the other hand, the purchasing power of Europe, as a result of war's impoverishment, will inevitably be greatly impaired and the surplus production available for export may soon be as great as before the war.

According to the best opinion of economists we cannot long maintain the artificially high scale of prices for materials and for labor which now prevail because Europe is borrowing money to spend like water. A merchant may prosper amazingly from the custom of patrons who are spending borrowed money; but when they stop borrowing and become his competitors there is a different story. The high wages and short hours established in 1916 may not all be permanent.

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Levee-Building Machines Show Up Well in Test

Nearly all of the Mississippi River levees are simple earth embankments built with mules and scrapers with methods hardly improved in the thirty-odd years of such work. Figures of cost have necessarily varied with time and location, but a fair average is that on the Lower Yazoo district, where in 30 years some 26 million cubic yards of levees were placed at an average cost of 18c. per cu.yd. In times of emergency, as noted by Major Slattery on another page, this cost was apt to jump to 25 to 35c. per yd. Under such conditions it was but natural that those in charge of the Mississippi work should turn to mechanical devices, especially as the field of earth moving has developed so remarkably in the past few years.

In Major Slattery's article the first results of this move toward modern methods are outlined. The results are most satisfactory and the prospects of developing efficient machines most encouraging. Costs as low as 8c. per cu.yd. have been made and the prospective average seems to be from 8 to 14c. per yd. If the Humphreys bill, which passed the House last week with a total appropriation of $45,000,000 (plus a half of that sum imposed upon the States and levee districts), passes the Senate and receives the President's approval the building and enlarging of levees will increase beyond all previous expectations. The added protection made possible by the lowered cost of machine buildings makes imperative the further application of such methods and the discarding of the primitive horse and man labor, particularly if the modern way makes equally good levees.

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The world's wisdom is sure to be increased if a bill proposed to the legislature of Massachusetts goes through. The bill reads:

> Resolved, The Public Service Commission is hereby directed to investigate the relations existing between railroads and railways in this commonwealth; how the facilities of each may be changed, to the end that there may be coöperation between the railroads and railways in the transportation of passengers and freight, and report their findings to the next general court on or before Jan. 15, 1917.

The relation between "railroad" and "railway" has been a mystery these many years. This much is known: They have been the faithful gold-dust twins of lawyers connected with transportation matters and have coöperated very well indeed, as Tweedledum and Tweedledee. Therefore, the proposed law is quite unnecessary in so far as it seeks to procure coöperation.

Or is it possible that the bill refers to a steam Tweedledum and an electric Tweedledee?

Letters to the Editor

Success in Engineering

Sir—The writers of the various letters in your issue of May 11, in regard to the qualifications for success in engineering, all seem to lose sight of the fact that the object of this inqury, as I have understood it from the statement made by Professor Mann at the last annual meeting of the American Society of Civil Engineers, is to determine the best method of educating engineers, and, while it may be true that the qualifications named are in the order of their importance those most necessary for the successful engineer, it does not seem to me that they are the qualifications which can be expected from the engineering student, or even graduate.

Character and integrity should be taken as a matter of course, but character is not formed without experience. Efficiency, judgment, perspective, understanding of men, and executive ability can only come from experience, and cannot be taught in any engineering school.

I think we are losing sight of the fact that our engineering schools should above all things else ground the students in the *principles* of engineering, and while they should be informed that the other qualifications are necessary to their future success in their profession, they should also have a full comprehension that without a complete and full knowledge of technical principles they cannot hope to succeed. This point of view was pointed out by me to Professor Mann, but apparently had no influence in the composition of the second circular which was sent out. But it does seem to me that this is a point of view which those responsible for the education of engineers should have in mind. F. Lavis.

New York, May 12, 1916.

Getting Grease and Fertilizer from City Sewage

Sir—The experiments on the Miles process of treating sewage by acidulation as carried out at Boston by E. S. Dorr of the Sewer Department since 1911 and more recently by Prof. R. S. Weston of the Massachusetts Institute of Technology, and described in *Engineering News* of May 11, 1916, will no doubt attract the attention of sanitary engineers. The margin between the cost of sludge disposal and the revenue recoverable from its valuable constituents is not likely to be wiped out soon—perhaps never, in the average installation. But it is gradually being narrowed so that, without expecting a net profit, unless in exceptional cases, it is probable that there will be an increasing number of treatment plants where the cost of sludge disposal *may be* appreciably reduced by the separation and sale of the grease and fertilizing constituents. Whether it *will* be is another matter, for, as pointed out by George T. Hammond[1] in his discussion of the activated-sludge problem, the more attractive proposition of garbage utilization is up to the present time neglected in all but 26 of our 199 cities having a population exceeding 30,000. But it is believed that there will be a tendency toward utilization due to advances in the art of sludge treatment and also to the enormously increased demand of late years—even before the war—for nitrates. It has been estimated that the supply of Chile saltpeter—the only supply of any magnitude now known—will be exhausted within 50 years, and although the fixation of atmospheric nitrogen may supplant the natural supplies to a considerable extent, the power required for its production is limited and will tend to appreciate in value as time goes on. For these reasons it is believed that dried sludges high in nitrates or ammonias will become more marketable than in the past.

The grease in many sewages is, however, by far the most valuable ingredient, while at the same time a detriment to the use of sludge as a manure, and in the recovery of this the Miles process appears to be particularly effective. As indicated by Prof. Weston, there may be recovered from sewage containing 51.6 p.p.m., 430 lb. per million gallons by the use of a ton of SO_2, or, according to Mr. Dorr, 393 lb. per million gallons by the use of 1.1 tons of H_2SO_4, at an estimated cost of some $18. This amounts to about 0.215 lb. of grease per pound of SO_2 or 0.178 lb. per pound of H_2SO_4. The market value of the grease and the tankage being about $24, the net profit is estimated at $6 per million gallons of sewage.

The Miles process is similar in many respects to that employed for many years at Bradford, England,[2] except in the source of the grease, which in this case is mostly from wool-scouring, and in its amount, which is 440 p.p.m. or 8½ times that found at Boston. At Bradford 2.75 short tons of H_2SO_4 are used per million U. S. gallons, producing about 2,340 lb.[3] of grease or 0.43 lb. per pound of H_2SO_4, while at Boston there is produced just one half that amount or, as already stated, 0.215 lb. per pound of acid. The difference is probably due to the great difference in the amount of grease in the raw sewage.

The estimated tankage at Boston is 0.68 and at Bradford 3.65 short tons per million U. S. gallons.

The revenue from the sales of grease and tankage at the latter place amounted to about $140,000 in 1912 or $22.80 per million U. S. gallons, which was something less than the gross cost of treatment.

H. W. Clark places the theoretical value of the fertilizing and fatty ingredients of sewage at from $60 to $80 per million gallons[4] and the Metropolitan Sewerage Commission of New York[5] estimated the theoretical value of that city's sewage in 1910 as about $18,600,000, all of which is wasted. In England its value has been estimated by Dr. Grossman of Manchester at over $100,000,-

[1] "Engineering News," Apr. 27, 1916, page 799.

[2] See "Engineering and Contracting," Vol. XL, Nov. 26, 1913, page 601.

[3] Sixteen to 20 long tons per day from 14 million Imperial gallons. "Sewage Disposal," Kershaw, page 150.

[4] "The Fertilizing Value of Sewage and Sewage Sludge," 1914.

[5] Report, 1914, page 349.

000 per annum, and Dr. Gilbert Fowler, until lately also of Manchester, has stated "that there is an almost unlimited outlook for properly prepared sewage manure, either alone or as a basis for the enrichment of artificial fertilizers."[6]

Any method which promises to conserve even a small portion of such values should be encouraged, but past experience has not been such as to create optimism. If the acid process is tried out on a large scale at Boston it will at least furnish information of value to other communities. Its success here, however, would not mean that it would supplant other well-known methods to any great extent, for at Boston the sewage contains a larger amount of grease than the average, and a large volume can be handled from the start, utilizing the ample storage tanks already built at Moon Island. It is also probable that in the yearly operation of a full-sized plant the resulting efficiency would be much lower than in a carefully conducted experiment and this difference might easily wipe out any anticipated profit. In short, it is extremely doubtful if so elaborate a treatment of the sludge would ever be profitable except in dealing with rather large volumes of sewage rich in fatty matters; but where these conditions occur it may be that the Miles process, with its alleged freedom from odor, the sterility of the effluent and the high stability of the sludge, will be shown to have sufficient merit for serious consideration.

Further experience with its use at Boston will be looked for with interest. KENNETH ALLEN,

Engineer of Sewage Disposal, Board of Estimate.
New York City, May 15, 1916.

Montreal Centrifugal Pump

Sir—The editorial entitled "Triple Expansion Still Ahead" in your issue of May 18 might give the impression to the casual reader that the information originally supplied regarding the test of the De Laval steam-turbine-driven centrifugal pump at the Montreal low-level pumping station was intentionally misleading.

I therefore wish to point out that the steam consumption used in figuring the duty of 168.3 million was taken according to the method agreed upon by the City of Montreal, viz., the pumping unit to be charged with the steam actually consumed by it and by the auxiliaries, less an amount of steam equivalent to the heat imparted to the boiler feed water in the primary and secondary heaters.

This is a simple and easily understood basis of comparison and is not "an impossible, hypothetical duty based on utilizing the entire heat in the steam," as asserted by you. In fact, it is the only simple and sensible method for figuring duty where partially expanded steam is used for preheating, an operation which, as has long been known, is an improvement upon the strictly Rankine cycle. GEORGE H. GIBSON.

Tribune Building, New York City, May 19, 1916.

[It was not intended to intimate that the builders of the Montreal unit had issued the statement in question with any idea of gilding the truth. What we objected to, and with reason, is the statement that the duty of a pumping unit is anything more, or less, than that defined by the American Society of Mechanical Engineers' Test Code. What the builders called "duty" required a special warning that it was not duty as understood by water-works engineers. Sooner or later such a qualification of the term was bound to drop out and misunderstanding to arise. Any arrangement between the builders and purchasers of such machinery is proper that promotes easy adjustment of commercial obligations; but when either party publicly discusses the results of their work the contract terms should be translated into generally accepted nomenclature.—Editor.]

[6] "The Surveyor and Municipal and County Engineer," Mar. 20, 1914.

More on Rock-Filled Dams

Sir—The recent failure of the lower Otay rock-fill dam has renewed an old subject of discussion which was very freely waged in the early nineties by the engineering profession, following the failure of the Walnut Grove dam in Arizona, Feb. 22, 1890.

In this early discussion the most generally accepted conclusion was that a properly designed rock-fill dam, constructed of suitable materials and properly safeguarded, was a safe and satisfactory type and should be adopted wherever it could be used with commercial economy.

On July 7, 1890, the writer as consulting engineer of the Escondido Irrigation District made a report advising as one of the necessary features of the proposed works the construction of a rock-fill dam at the point where it was later built. This proposed type of dam raised a local tempest, as the Arizona disaster was fresh in the minds of the district residents. To a great degree and largely through the presentation of an analysis of the resistance of the Walnut Grove dam when subjected to a heavy overflow for which it was not designed the writer successfully satisfied criticism and objections.

The original design of the Escondido rock-fill dam provided for a top elevation 110 ft. above bedrock and a top width of 10 ft., with a coefficient against sliding of 3.5; it provided also an overflow weir at an elevation of 102 ft. above bedrock, located in a saddle remote from the dam.

The plans called for hand- and derrick-placed rock in both faces—the upper face 20 ft. thick at the bottom and 10 ft. thick at the top, the lower 28 ft. thick at the bottom and 5 ft. at the top. The core was to be of loose rock free from earth, sand, gravel and spalls. The upper face was to be covered with concrete thoroughly anchored into the rubble.

The present dam was completed five years later with the following changes from the original plans: The height was reduced to 76 ft., the upper face was planked, the lower slope was flattened in its lower half, and all rock was dumped loosely in place, excepting for a 10-ft. facing of hand rubble on the upstream side. The overflow weir was placed at the north end of the dam and constructed as a canal 20 ft. wide and 5 ft. deep.

The writer was not in charge of construction, but has always considered the principal element of danger in the revised plans to be found in the restricted spillway or waste weir.

During the recent storms this dam was overtopped for some 6 hr. with an overflow sheet of water said to have had a depth of 2 in. at the abutments and a greater depth at the center of the structure, where for some 60 ft. the

depth was in excess of 12 in. The rock-fill settled at some points as much as 1 ft. and a small quantity of rock on the lower face was displaced. That this structure is now standing is due solely to the fact that the body of the dam was composed of large rock with maximum voids free from spalls, gravel, sand and earth.

It is reported that the owners of the Escondido reservoir will soon build the dam to the elevation of the original design and take advantage of the low saddle in the watershed line to construct a long and safe waste or overflow weir.

The writer is not surprised that the Lower Otay dam failed immediately the lake level overtopped the structure, and he further believes that a failure with the water level at the spillway elevation would at least have been logical.

No rock-fill dam having a cross-section within the limits of commercial investment would possess inertia sufficient to withstand for any great length of time an overflow volume of water which could not readily escape through the voids of the structure. Even with open voids the structure would quickly fail, by erosive action of the water, if the overflow volume exceeded the absorption capacity of the rock-fill.

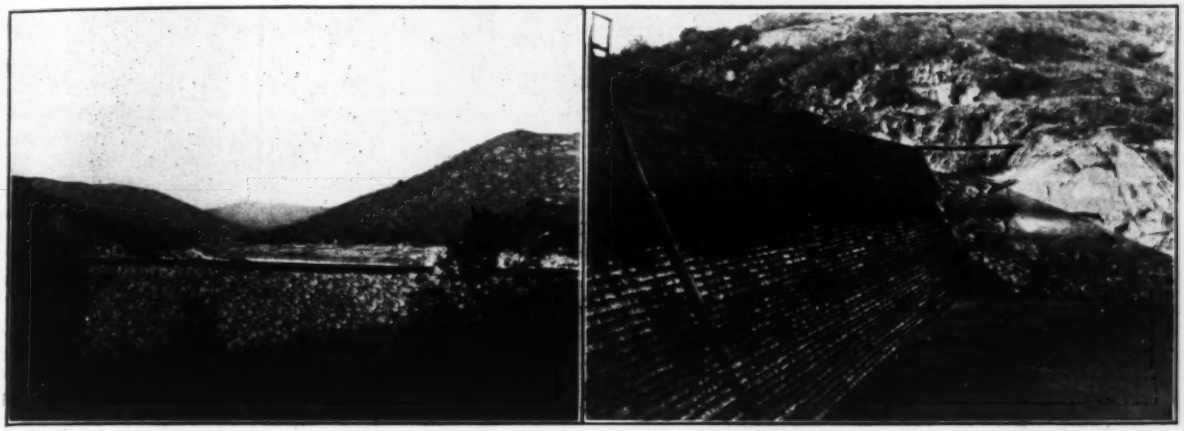
It is well to remember that disintegration of the rock mass in this type of dam is constantly at work, with the result that settlements and readjustments of, and within, the mass produce a tendency of the whole structure to slide downstream, when subjected to the increasing thrust produced by the rapidly rising reservoir waters.

From an examination of photographs representing the progress of work during the construction of the dam one gets a strong suggestion that too much fine material was allowed within the structure. This fine material coupled with the product of disintegration would largely reduce the voids in the mass and constitute a menace needing only a comparatively small quantity of water in the lower half of the dam to produce "blowouts" of such magnitude as to result in immediate destruction.

It is evident that the readjustments within this dam, as previously described, were sufficient to shear the thin composite "plate-metal and 2-ft. concrete" core wall and, further, that the leakage through the fractured core wall quickly saturated the rock mass below and produced the complete failure of the structure.

Eyewitnesses of the 6-hr. overflow of the Escondido dam state that at the time of maximum overflow all water was absorbed by the voids of the mass within a few feet of the top of the dam and only appeared again at the base of the structure, where it left the rock-fill without producing erosive action.

In further support of the principle that rock-fill dams never should be used as overflow weirs the writer desires to call the attention of engineers to the monumental failures that may be found in many of the mountain cañons of western America. These colossal dikes, or "hog's backs," of broken rocks which in past geological times have slid into the cañons from the adjacent mountain mass have completely dammed the cañons and created lakes or reservoirs, in some cases hundreds of feet in depth; but in every case, so far as the writer has observed, these "natural rock-fill dams" have been cut through by overflow water and have failed as dams, notwithstanding the fact that in cross-section they were many times more conservative than any artificial structure yet erected.



FIGS. 1 AND 2. UPSTREAM AND DOWNSTREAM VIEWS OF ESCONDIDO ROCK-FILL DAM

The lessons to be learned from the recent action of these two California rock-fill dams are of great value to engineers and may be briefly stated as follows:

Rock-fill dams should never be constructed unless supplemented by the liberal use of "waste weirs" to insure against the overtopping of the structure.

Only hard, durable, crystalline rock, in large pieces, free from spalls and other fine materials, should be allowed in these dams.

These structures should be designed with a coefficient against sliding of not less than 3.5 and with a core wall at or near the upstream face of the dam.

Los Angeles, Calif., Apr. 1, 1916. F. E. TRASK.

A Scenic Automobile Highway to the top of Mt. Whitney is the ambitious scheme of the Board of Supervisors of Kern County, California, which recently adopted resolutions asking the Board of Supervisors of Los Angeles County and the Automobile Club of Southern California to coöperate in asking the assistance of the Federal Government to that end. Mt. Whitney is the highest mountain peak in California, its top being at 14,501 ft. above sea level. The length of the proposed highway from Bakersfield is 150 mi. Kern County agrees to put the present road from Bakersfield to Weldon in good condition, provided the Federal Government will construct the remaining 75 mi. of road from the town of Weldon to the summit of Mt. Whitney. This portion of the road, which is estimated to cost $343,000, will lie within the Sequoia National Forest Reserve.

Coating Steel at Grand Central Terminal With Cement Gun

By W. F. Jordan*

SYNOPSIS—Over 1,000,000 sq.ft. of 2-in. concrete fireproofing applied to steelwork of the Grand Central Terminal at New York with cement gun. Resulting mortar hard and effective. Cost lower than by hand placing.

The tracks in the Grand Central Terminal at New York City are on two levels. The upper level is carried on a steel and concrete structure, the general design of which is shown in the photographs. The concrete jack arches were built before the fireproofing work was started, so the operating tracks on the upper level could be laid. This left the soffits of the stringers, the lower part of the girders, brackets and columns to be protected later by fireproofing.

A minimum thickness of 2 in. of fireproofing was required, and it was important that the fireproofing adhere closely to the steel to protect it from moisture and rusting as well as from fire. The cement gun was chosen to do the work, which was started in 1911 and is still continuing. Up to date about 1,000,000 sq.ft. of surfacing has been applied.

After the steelwork was cleaned and repainted wire lath was placed about 1 in. from the metal. This lath was made up of Clinton electrically welded cloth of No. 12 wire, 2x2-in. mesh and galvanized. The cloth was tied to ⅜-in. rods, which in turn were fastened to the structure. On the bottoms of girders the rods were bent over the flanges; on the sides of girders and brackets the rods were passed through holes in the stiffeners and tied between with No. 6 wire through holes punched in the web of the girders. The rods were spaced from 12 to 15 in. apart.

The cement guns are mounted on a low push-car so that the door by which they are charged comes just above the floor of a flat-car. This push-car is placed next to a standard flat-car on which is a shaking screen. The cement is kept on this car, and the cement and sand are mixed on it. The sand is brought in on cars and is placed immediately behind the mixing-car. The cement and sand are mixed, passed through the shaking screen and then shoveled into the hopper of the cement gun as required. The gun blows the dry mixture through a 1-in. hose, and the nozzleman directs the stream onto the steel to be protected. Water is taken to the nozzle through a separate hose and is sprayed into the mixture at the nozzle, the nozzleman having a valve to control the amount of water. He plays the stream back and forth until the desired thickness is obtained.

It is found best to apply the coating in two layers. Trains are running on the tracks laid on the roof of the structure, and the jar from the moving trains was apt to shake the fireproofing off, if it was all put on at one time; but when put on in two layers, there was no trouble. On the sides of the girders there is a tendency for the sand to fall down into the angles of the structure and make porous places next to the steel. This was prevented by shooting the top of the bottom flange first, filling the angles before the space between them.

After shooting, a mason trims off the irregularities and floats the surface. In applying the mixture a part of the sand rebounds and is lost; a part is shot by the edges of the structure, and some is scraped away by the mason trimming off the irregularities. It is estimated that from 15 to 20% is lost.

The coating has a minimum thickness of 2 in., but owing to irregularities in the steel and rounding out the fireproofing in the angles the average thickness is from 2½ to 3 in.; generally it is about 3 in.

The mixture used is 1 cement and 3 sand. This makes a very hard and dense coating. To test the density, some of the mixture was wetted and applied with a trowel as mortar; after setting, this was found to weigh 124 lb. per cu.ft. Some of the fireproofing applied with the cement gun was weighed after setting and was found to weigh 144 lb. per cu.ft. It is very hard and when set requires a chisel to cut it. No cracks have appeared in the fireproofing except in the pipe subway, where there were hot pipes at the time the work was put on; the heat dried out the mortar too quickly, producing hair cracks.

The machine has been used successfully with 250 ft. of hose, but an effort is always made to keep the hose as short as possible. During the early operation the best hose available wore so rapidly that with a 100-ft. length on a machine the cost of hose ran as high as $5 per day. Manufacturers now make a hose adapted to the service, and the cost has been reduced to 75c. per day. Care is taken to avoid short bends, and the hose is turned end for end occasionally.

The area covered per gun per day has averaged 600 sq.ft., and where conditions were very favorable as much as 1,200 sq.ft. has been done in a day. To cover 600 sq.ft. the material required on an average has been 94 bags of cement and 9.4 cu.yd. of sand. The most material that has been passed through a machine in one day is 125 bags of cement and 14 cu.yd. of sand. When the large areas around 1,200 ft. were obtained, it was in places where the steel had fewer irregularities and the average thickness was less than for the general run of the work.

The sand for the cement gun should be sharp, not too coarse, and rather dry; very dry sand and wet sand do not work well. Care is taken that pebbles do not get into the machine. They are likely to clog the hose.

The reinforcement is put on by contract. The concreting is handled by a foreman with a man to operate the machine, four laborers to mix and screen the ingredients and charge the machine, a nozzleman to apply the mixture and a mason to finish the work. Frequently some additional work is needed, and men are called from other places to attend to it. Much of the work has been over tracks in revenue operation, and an operating watch-

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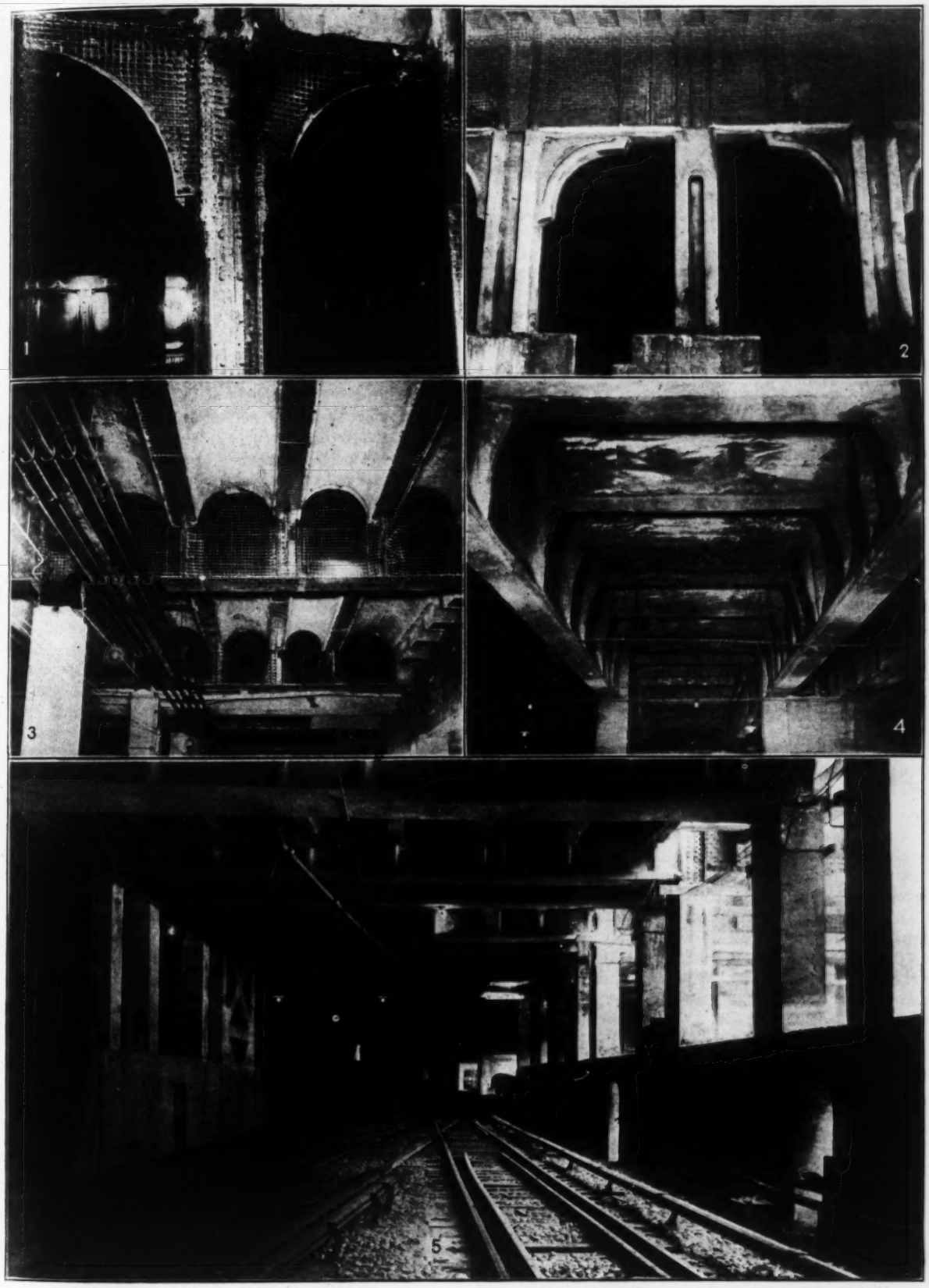


FIGS. 1 TO 5. FRAMEWORK OF GRAND CENTRAL TERMINAL FIREPROOFED WITH CEMENT-GUN MORTAR

Fig. 1—Wire mesh on column before mortar application. Fig. 2—Column coated with mortar, girders and floor with reinforcement in place. Fig. 3—Complicated jack arch construction partly coated. Fig. 4—Completed ceiling coating. Fig. 5—Completed track bay, showing how close to traveled tracks work had to be done

man is required to protect the workmen. Some of the sand drops into the ballasted track below, and there is a charge for the cost of cleaning the ballast. There is also some expense for protecting the third rail The machine uses 100 cu.ft. of free air per minute, compressed to 40 lb. Four men are employed to handle the scaffolding, and the cost of this part of the work is divided between the painting and the fireproofing. The accompanying table gives some average costs of the cement-gun work. An attempt was made at putting the fireproofing on by hand. The cost was 35c. per sq.ft. exclusive of the lathing.

COST OF FIREPROOFING FOR A DAY'S RUN OF 600 SQ.FT.

Scaffolding, charged to fireproofing		$7.20
Labor		26.00
Material:		
94 bags of cement at 32c	$30.08	
9.4 cu.yd. of sand at 50c	4.70	
		34.78
Compressed air		3.50
Watching, cleaning ballast and protecting third rail		3.25
Supplies and repairs		2.00
Switching service		1.00
Interest and depreciation, superintendence, office expense and incidentals		13.27
Total		$91.00

$91 ÷ 600 = 15⅛c. per sq.ft.

In the accompanying views the various stages of the structure are shown from bare steel, with wire attached, to the finished fireproofed steelwork.

Some Important Details of Land Drainage Work

In a report on drainage in the lower peninsula of Michigan, A. D. Morehouse, Drainage Engineer of the United States Department of Agriculture, makes very pertinent comments on the various problems of construction and maintenance of land drainage systems in general, using the practice in that locality for the basis of study.

There is little uniformity in the cost of trenching and laying tile, especially in contract prices for county work. Figures show a range of 36c. per rod for 8-in. tile drain (average cut, 1½ ft.) to $1.69 for 8- and 12-in. tile (4-ft. cut), and $4.34 for 10-in. tile and 6-ft. average cut. The difference is far beyond what might be accounted for by variation in soil or the presence of timber.

The accompanying table gives an interesting review of the distribution of cost on 84 drains aggregating 131 mi. in one county. The total cost was $152,438, averaging $3.63 per rod, or $1,161.44 per mi. Of the total, 83.26% was for construction, 9.67% for office and miscellaneous expenses, and only 3.41% for engineering.

DISTRIBUTION OF COST OF TILE DRAINAGE

	Per Cent.		Per Cent.
Surveys and plans	3.13	Additional work	2.91
Printing notice of letting	1.90	Office work	2.24
Construction	47.15	Probate fees and exp. of	
Tile and hauling	29.80	commrs. of jury	2.54
Culverts and arches	5.75	Damages allowed	0.05
Inspection	0.28	Balance on hand	4.22

From a study of ditch profiles it is evident that the desire to save excavation by keeping the grade as nearly as possible at a uniform depth below the surface has been a ruling factor in ditch design. In this way the hydraulic features are overlooked. The result is insufficient depth of outlet for lateral ditches and the running of a steep grade into a flatter one. This latter feature causes slacking of the velocity of the water and deposition of silt, and also the danger of having too little capacity in the ditch with the flatter gradient. The first consideration should be to secure the desired drainage results by a ditch that will be as nearly self-maintaining as possible. The amount of excavation necessary should be regarded as a secondary matter.

In few cases were the size and fall of the ditch so designed as to give it a capacity determined from the topographical and geological character of the watershed, in connection with the rainfall data. Such details have been simply matters of the drain commissioners' judgment or convenience, rather than of an engineer's study and calculations.

The efficiency of drainage works is not gaged by their ability to handle rainfalls of average amount, but they must be of sufficient capacity to take care of the maximum storms which (while occurring at infrequent intervals) must be provided for within a short space of time, if crop injury or destruction is to be prevented. It is probable that a runoff of ¼ to 1 in. of water from the watershed in a 24-hr. period would be the ordinary range for the varying topography and soils of this section. The exact amount must be determined after consideration of the local conditions.

There is a marked tendency to make ditches wide and shallow rather than deep and narrow. Except in cases of necessity, where sand, quicksand or rock would be encountered, the latter are more desirable. They furnish better and deeper drainage, are more easily maintained, have greater carrying capacity for a given amount of excavation and require less width of right-of-way. The berm at the top of the ditch should be of such width that when the banks of the ditch take their natural slopes none of the spoil will fall or be washed into the ditch. For ordinary dredged ditches of moderate depth this width will be from 8 to 10 ft. as a minimum.

While ditches should be as straight as practicable, they should usually follow natural drainage depressions or channels except where these latter may be straightened conveniently and economically and without danger of flooding low lands lower down the stream.

The cleaning of ditches is often left for a number of years (averaging 10 yr. in one lot of ditches investigated, with a maximum of 36 yr.). In many cases it is a virtual reconstruction of the ditch. Under ordinary circumstances, in the section under consideration, a new ditch properly constructed should require little attention or repair for three years, but it should afterward be given annual attention. In case of any exceptional obstruction such as the overthrowing of trees into the ditch by storms, the matter should be remedied at once without waiting for the annual overhauling.

It is probable that from 1 to 2% of the original cost of a ditch, spent annually in the removal of weeds, silt, logs, trees or other obstructions, will keep the ditch up to its original efficiency and prove of benefit to the adjacent lands.

Much damage to new ditches has been caused by animals, owing to the failure of landowners to fence the ditches at the time of construction. It has been suggested that it would be proper to make the original cost of such fences a part of the cost of the ditch. After the fences are built, the landowner should be required to maintain them.

In many cases county drains have been impaired or ruined by lateral tile drains or ditches entering the main ditch without any protection being provided for the latter.

News of the Engineering World

Nashville Engineers Active in Society Work

The Nashville, Tenn., section of the Engineering Association of the South has ended a one-week membership campaign, which added 55 new members, bringing the total to 140. The campaign was carried on by two teams of six men each, called the "Squares" and the "Triangles." The Squares, led by M. A. Lightman, attained the higher record, and was presented with a loving cup inscribed with the name of the successful campaigners.

The section has also offered a medal to the member who writes a paper for the local press which, in the opinion of judges, does the most good for the society. The subjects are to be submitted to the society for approval and should aim to show what engineers (and particularly the society) are doing for the public.

A movement recently started by the section has as its aim the inclusion of at least one engineer in the proposed convention to revise the state constitution. Other engineering societies of the state are to be asked to aid in having engineers nominated delegates to this convention. The section will appoint a committee to work with other engineering organizations with the idea of submitting suggestions to the constitutional convention.

New York May Use More Meters

Some of the most serious limitations on the use of water meters in New York City have been removed by a legislative act signed by Governor Whitman on May 19. The principal changes effected or made possible by the act have been summarized for *Engineering News* by Delos F. Wilcox, Deputy Commissioner of Water-Supply of New York City, as follows:

1. The Department, with the approval of the Board of Aldermen, may assume the expense of furnishing, installing and maintaining meters, thus changing the system from private ownership to city ownership of meters.
2. The Department, with the approval of the Board of Aldermen, is authorized to acquire meters now owned by the property owners and to assume the expense of keeping them in repair.
3. The right to demand the installation of a meter is extended to every property owner connected with the public water supply.
4. The city is authorized to establish annual service charges and minimum charges in connection with a schedule of meter rates.
5. The Department is authorized to apply the revenue from service charges to the financing of the meter system.
6. The method of estimating the amount of water used while the meter is out of repair is made more elastic.
7. The consent of the Board of Aldermen to the installation of meters on residential premises will no longer have to be given for all or none, but may be given for "any or all," thus enabling the Board of Aldermen, if it sees fit, to classify residential premises and give its consent to the installation of meters in one or more classes.

A review of the New York meter situation, based on an official statement, appeared in *Engineering News* for April 6, 1916, page 657, accompanied by editorial comment on page 665.

Engineers Hold Nationwide Telephonic Session

A memorable national meeting was held by the American Institute of Electrical Engineers on May 15. The meeting involved simultaneous sessions in San Francisco, Chicago, Atlanta, Philadelphia, Boston, Salt Lake City, Denver and New York, and they all were tied together by means of long-distance telephone circuits, 5,000 receivers being employed by the large and scattered attendance. The hour of meeting varied in the different time zones to correspond with 8:30 p.m. Eastern time. The meeting commemorates the achievements of the Institute's membership in the field of communication, transportation, lighting and power.

At exactly 8:30, President John J. Carty in New York called the great meeting to order and requested reports from the section officers presiding in the other cities. Each responded with a statement that his city was in session with such and such an attendance. The attendance was as follows: Atlanta, 500; San Francisco, 750; Chicago, 1,000; Boston, 900; Philadelphia, 850; New York, 1,100. Denver and Salt Lake City, though able to hear the proceedings of the meeting, were not able to take part otherwise. During the course of the evening these two cities telegraphed their attendance, which was 40 for Salt Lake City and 50 for Denver, making a total of 5,200 throughout the country.

At 9 o'clock, Eastern time, the telephonic connections were discontinued for a half-hour to permit local addresses to be delivered. When the national character of the meeting was resumed, general greetings were exchanged and national airs rendered by phonograph. Following this, Dr. Michael I. Pupin addressed "The Engineering Profession." Following this address was a general greeting from Honorary Secretary Ralph W. Pope.

Aberdeen Buys 2,000,000 Ft. of Staves for Water Conduit

Wood staves for the new water-supply conduit of Aberdeen, Wash., will be supplied by local mills through the Pacific Lumber Agency at $25 per 1,000 ft. An earlier report (*Engineering News*, May 4, 1916, p. 869) stated that 1,000,000 of the 2,000,000 ft. in this order would be furnished by the Vance Lumber Co. for $23 per 1,000 ft., f.o.b. Malone, Wash., but that company has released the city from obligation to it. Freight at $1.20 per 1,000 ft. and the greater cost of inspection at Malone, it is held, will just make up for the increased contract price. Under the contract just awarded the staves may contain one knot 1 in. or less in diameter every 4 lin.ft., and these knots may be on the edge of the staves. For $3 more per 1,000 ft., knots only ½ in. in diameter, extending only part way through the stave, with none at the edge, might have been obtained. L. C. Kelsey,

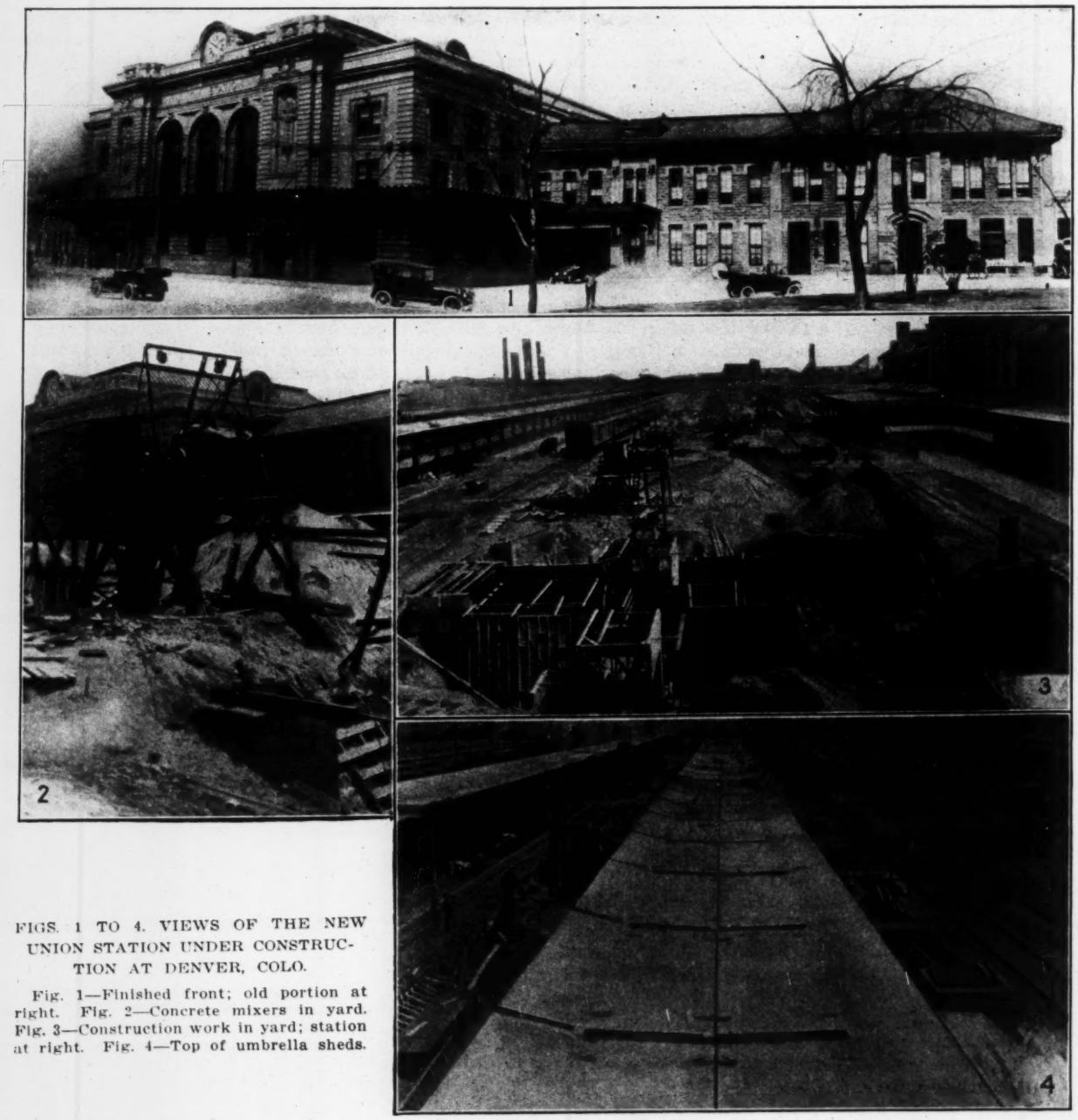
City Engineer, advised the cheaper staves, stating that they would make a durable pipe line and that the same grade had been used for the Cedar River conduits, Seattle. Two councilmen voted against the cheaper staves. The conduit will be 28 in. in diameter and 22 mi. long. Bids for laying it are to be received on May 31.

Union Station at Denver, Colo., Nearing Completion

The reconstruction of the union station at Denver, Colo., by the Denver Union Terminal Railway Co., the plans for which were described in detail in *Engineering News*, Apr. 1, 1915, is now nearing completion. The accompanying views were taken at the end of April, 1916. The work is complicated by the fact that the station building, yard and tracks have to be kept in operation during the changes. The new station building has been completed for some time, and work on the rearrangement and elevation of tracks and the construction of subway passages to the train platforms is progressing rapidly.

Fig. 1 shows the station building. The central portion (165x140 ft.) is new. It contains a large waiting room, the full height of the structure, with galleries around the outside leading to the offices. The older portion of the structure, forming the wings, is used for baggage and express, dining room, etc.

The reconstruction of tracks and yard (a plan of which was shown in *Engineering News*, Apr. 1, 1915) involves the handling of 55,000 cu.yd. of material, the tracks being raised about 3 ft. There are about 150 passenger train movements a day to be taken care of during these



FIGS. 1 TO 4. VIEWS OF THE NEW UNION STATION UNDER CONSTRUCTION AT DENVER, COLO.

Fig. 1—Finished front; old portion at right. Fig. 2—Concrete mixers in yard. Fig. 3—Construction work in yard; station at right. Fig. 4—Top of umbrella sheds.

changes. While essentially a terminal station the tracks are continuous through the station yards. Figs. 2 to 4 show some of this reconstruction work.

The umbrella-type of platform shelters of reinforced concrete form an interesting feature of the station. They are very similar to those recently erected by the Southern Pacific Ry. at Los Angeles and at the 3rd and Townsend St. station, San Francisco. The Denver station contains 6,700 lin.ft. of these shelters. Expansion joints are provided approximately 340 ft. apart, a sheet of galvanized metal being placed over each opening to keep water from dripping to the platform below. Fig. 4 shows some of these sheds completed.

The sheds are built of separately cast units placed by means of a locomotive crane. The pedestals were cast in place. On these were set the precast posts, and on the posts the roof slabs, precast in 20-ft. units. The posts are joined to the pedestals by 1 in. of cement grout.

The other views show the construction of the subways, of which there are three—one for passengers and one each for baggage and for mail and express matter. These are all to be served by electric elevators. The forms for the concrete are of wood, made in large units, and are moved from place to place by locomotive cranes. For concreting these subways small mixers erected on timber towers are used, and the concrete chuted into place (see Figs. 2 and 3).

The Denver Union Terminal Railway Co. is composed of six railways, represented by the following: J. G. Gwyn, Chief Engineer of the Denver & Rio Grande R.R. (chairman); E. F. Vincent, Chief Engineer of the Colorado & Southern Ry.; C. F. W. Felt, Chief Engineer of the Atchison, Topeka & Santa Fe Ry.; T. E. Calvert, Chief Engineer of the Chicago, Burlington & Quincy R.R.; C. A. Morse, Chief Engineer of the Chicago, Rock Island & Pacific Ry., and R. L. Huntley, Chief Engineer of the Union Pacific Ry. Until his death recently F. C. Cowan, Chief Engineer of the Colorado & Southern, was chairman of this engineering board. C. C. Post, former Division Engineer of the Union Pacific Ry., is Construction Engineer. Stocker & Fraser, of Denver, are the general contractors; the Van Sant-Houghton Co., San Francisco, has the contract for the concrete umbrella sheds; and Hinchman & Renton, Denver, are contractors for the piping and drainage of the yard. The work was begun in September, 1914. The total cost of the improvements approximates $4,000,000.

A Blast Demolished a Restaurant in Akron, Ohio, on May 15, killing 9 persons and injuring 28 others. The cause of the accident was blasting in an excavation for a new building next door to the Crystal restaurant on Main and Quarry St. The building collapsed immediately after the blast. There were 35 diners and 15 employees in the wrecked building. The property damage is estimated at $25,000. The building is of one story, having a two-story false front, and was built in 1886. It was only 20 ft. wide. The false front toppled backward, falling upon the collapsing roof. Three weeks ago another blast damaged a part of the wall of the Strand Theater, north of the excavation. In the report of three state inspectors—made public on May 19—the excavating contractor is blamed for the accident. The careless blasting took place in spite of safety orders issued by the city.

Road Institutes in 30 Alabama Counties, held recently under the State Highway Commission (W. S. Kellar, Engineer), were attended by 1,745 people, of whom one-third are actually engaged in roadwork.

The Building-Trade Strike in St. Louis was settled on May 18 by a compromise which gave the hodcarriers and building laborers an average of about 2½c. an hour increase, and a further agreement that there would be no discrimination on account of union affiliation.

Philadelphia Public Improvements to the amount of $115,000,000 were authorized by a vote of 3 to 1 on May 16, when the electorate approved the issue of bonds submitted by the Councils. This amount is to be distributed as follows: Transit development, $57,100,000; new diagonal parkway and boulevard, $9,000,000; port improvements, $5,000,000; grade-crossing removal in South Philadelphia, $5,640,000; sewage treatment, $3,200,000. General improvements take up the remainder.

The Humphreys Bill providing appropriations for the flood-control of the Mississippi and Sacramento Rivers and establishing precedent for Federal expenditure in all flood-control work passed the House of Representatives on May 17. The bill is the same as noted in "Engineering News," May 18, 1916, p. 954, except that an amendment was carried providing that local interests along the Mississippi should contribute one-half as much as the Federal government instead of the one-third specified in the original bill.

Municipal Improvements at Erie, Penn., to cost $1,445,000 were indorsed by a 4 to 1 popular vote on May 16, when bonds for that amount were authorized. Most of the sum will go for stream control, $950,000 being devoted to the improvement of Mill Creek and $200,000 to Garrison Run, a small stream in the eastern part of the city. Grade crossing elimination will take $225,000 of the total and storm sewers $70,000. B. E. Briggs, city engineer, writes "Engineering News" that work on plans for the improvements will be started at once in order that contracts may be let at the earliest possible date.

Limits of New York Harbor—Suggestions respecting the lines designating the waters of New York Harbor, as contemplated by the Seaman's Act, have been made by the committee appointed for the purpose and the report has been approved by Secretary of Commerce Wm. C. Redfield. The committee consisted of Assistant Secretary of Commerce E. F. Sweet, chairman; A. L. Thurman, solicitor of Department of Commerce, and Supervising Inspector Gen. George Uhler, of the Steamboat Inspection Service. Suggestions and opinions of interested persons were received by this committee at a hearing in New York City on Apr. 26, a unanimous report of which has now been made. The harbor limits suggested are as follows:

The limits of the harbor seaward shall be an imaginary line drawn from Navesink Lighthouse, 25½° true (NE. ⅞ N. mag.), to the Life Saving Station on Rockaway Beach, and all waters inside of this line to the northward and westward shall be considered as within the limits of New York Harbor.

The limits of the harbor eastward and meeting Long Island Sound shall be an imaginary line drawn from Eatons Point Lighthouse on the north shore of Long Island, N. Y., 9½° true (N. by E. ¾ E. mag.), through the lighthouse on Pecks Ledge to the Connecticut shore east of the Saugatuck River, and all the waters inside of this line to the westward shall be considered as within the limits of New York Harbor.

Another Scholarship in Chemical Engineering—The Chemists' Club of New York has announced the establishment of another scholarship fund, the income from which, approximately $400 per year, is to be devoted to assisting financially deserving young men to obtain education in the field of industrial chemistry or chemical engineering. This scholarship has been endowed by William F. Hoffmann. Its benefits will be open to properly qualified applicants without restriction as to residence and may be effective at any institution in the United States which may be designated or approved by the Chemists' Club. Applicants must, as a minimum qualification, have completed a satisfactory high-school training involving substantial work in elementary chemistry, physics and mathematics and present a certificate showing that they have passed the entrance-examination requirements of the College Entrance Examination Board or its equivalent. Preference will be given to young men who have supplemented these minimum qualifications with additional academic work, especially in subjects which will form a suitable foundation for the more advanced study of applied chemistry and chemical engineering. All inquiries should be addressed to the Hoffmann Scholarship Committee of the Chemists' Club, 50 East 41st St., New York City. Applications for the academic year 1916-17 should be in the hands of the committee on or before June 1, 1916. William F. Hoffmann, the founder of the Hoffmann scholarship, is president of the American Oil and Supply Co., Newark, N. J. He is one of the founders of the Chemists' Club of New York.

PERSONALS

Mr. O. J. S. Ellingston, Assoc. M. Am. Soc. C. E., formerly City Engineer of Sherman, Tex., has been appointed City Manager of that city.

Mr. L. W. Cady has been promoted to the position of Efficiency Engineer of the Division of Light and Heat of the City of Cleveland, Ohio.

Mr. A. L. Mohler, President of the Union Pacific R.R., has announced his retirement from active service, to take effect on July 1. Although he retires as President, he will be identified with the system in an advisory capacity.

Mr. William von Phul, M. Am. Soc. C. E., Vice-President and General Manager of the American Cities Co., and a member of the firm of Ford, Bacon & Davis, will succeed Charles N. Black as Vice-President of the United Railroads of San Francisco.

Messrs. Clarence P. Day and S. H. Phelan announce that the firm of Day & Phelan, Civil and Landscape Engineers, with offices in the First National Bank Building, Santa Barbara, Calif., has been dissolved. The business of the firm will hereafter be conducted by S. H. Phelan, at the same address.

Mr. H. H. Maxfield, M. Am. Soc. M. E., recently promoted to Superintendent of Motive Power of the Western Pennsylvania division of the Pennsylvania R.R., was born in 1873. He was educated at Stevens Institute of Technology and entered the service of the Pennsylvania R.R., as apprentice in the Meadow Shops, in 1865.

Mr. A. B. Gates, formerly Assistant Electrical Engineer of the Sanitary District of Chicago, and recently an assistant to Gardner S. Williams, consulting engineer, in valuation and accounting work, has entered the engineering department of the Commonwealth Edison Co., Chicago, as Engineer on Generating Stations.

Mr. George C. Andrews, Assoc. M. Am. Soc. C. E., until recently Resident Engineer of the New York State Barge Canal at Lockport, N. Y., has been appointed Supervising Engineer, Bureau of Water of the City of Buffalo, under the commission form of government. Mr. Andrews is a graduate of Lafayette College.

Mr. John Hugher, for 13 years General Manager of the Steel Products Co., a subsidiary of the United States Steel Corporation, has been made Assistant to President Farrell, succeeding W. D. Terley, who has been made Vice-President and General Manager of the new Canadian steel works to be built by the corporation.

Mr. Francis H. Wisewell, Jr., formerly connected with Westinghouse Church Kerr & Co., New York City, has been appointed Chief Engineer of the Gifford-Wood Co., Hudson, N. Y. Previous to his connection with Westinghouse, he was Mechanical Engineer with the Continental Car and Equipment Co., New York City.

Mr. F. L. Blendinger, Assistant to the Vice-President of the Lehigh Valley R.R., at New York City, has been made Vice-President in Charge of Operation and Maintenance of that railroad, and will continue to have his headquarters in New York City. Mr. Blendinger started railroad work, in 1878, as a messenger on the Erie R.R. at Little Valley, N. Y.

Mr. Frank R. Fisher, formerly in charge of the field work in the construction of the Market St. subway, Philadelphia, has been appointed engineer in charge of subway construction under the Philadelphia City Hall. His salary will be $6,000 a year. Mr. Fisher is a graduate of Lehigh University, and has been engaged in engineering work in Philadelphia for many years.

Mr. J. C. Allison, Assoc. M. Am. Soc. C E., formerly Assistant General Manager and Chief Engineer for W. H. Holabird, Receiver of the California Development Co. at Calexico, Calif., announces that on June 1 he will open offices for general engineering practice in the Anderson Building, now under construction, in Calexico. He will specialize in irrigation, drainage, silt investigation, municipal engineering and valuations.

Mr. Emil Diebitsch, M. Am. Soc. C. E., who was recently elected a Commissioner of the Town of Nutley, N. J., under the commission form of government, has been designated as Mayor-Commissioner of Public Affairs, Streets and Public Improvements, by his two fellow commissioners. Mr. Diebitsch is a graduate of Lehigh University. He is ex-President of the General Contractors' Association. In private business he is an engineer and contractor with offices in New York City.

Col. John Biddle, M. Am. Soc. C. E., Corps of Engineers, U. S. A., has been appointed Superintendent of the United States Military Academy, West Point, N. Y. He will relieve Col. Clarence P. Townsley, whose term has expired and who will be given a leave of absence before being assigned to duty in the Coast Artillery Division. Col. Biddle is a graduate of West Point in the class of 1881. He is at present stationed in Baltimore, Md., in charge of river and harbor improvement in that vicinity.

Mr. Francis L. Gilman, Fel. Am. Inst. E. E., Assistant General Superintendent of the Western Electric Co., Chicago, has been made Assistant Chief Engineer. Mr. Gilman graduated from Harvard University in 1895 and entered the employ of the New England Telephone Co. at Boston. In 1901 he took up switchboard engineering in New York City, and in 1906 was placed in charge of manufacturing for the company at New York City. In 1911 he was appointed General Manager of the Kansas City (Mo.) Telephone Co., and later became General Manager of the Bell Co. of Missouri.

Mr. Charles N. Black, Assoc. Am. Inst. E. E., has resigned as Vice-President and General Manager of the United Railroads of San Francisco. He will hereafter devote all of his time to the interests of Ford, Bacon & Davis, New York City, of which firm he is a member. Mr. Black has been located in San Francisco since 1907, previous to which time he was Vice-President and General Manager of the Metropolitan Street Ry., and Vice-President of the Kansas City Railway and Light Co. and the Kansas City Electric Light Co., all of Kansas City, Mo. He was Vice-President of the American Electric Railway Association from 1908 to 1913 and President of the Association in 1913 and 1914.

Mr. Fred C. Dunlap, M. Am. Soc. C. E., Consulting Engineer, former Chief of the Bureaus of Water and Filtration of the City of Philadelphia, has returned to the service of the city as Consulting Mechanical Engineer for advice in connection, particularly, with the design of certain parts of the Frankford Creek Intercepting Sewer. Mr. Dunlap entered the employ of the City of Philadelphia in 1898 as Assistant Engineer in the Bureau of Water, and was appointed Assistant Engineer in the Bureau of Filtration on designs in 1900. From 1902 to 1905 he was Engineer in charge of construction of the Torresdale filters. During 1906 and until May, 1907, he was Engineer of Design for the Jerome Park Filters in the Department of Water, Gas and Electricity, New York City, at which time he was appointed Chief Engineer of the Bureau of Filtration of Philadelphia. In September of the same year, when the Bureaus of Water and Filtration were combined, he was made Chief of both Bureaus and retained this position until his resignation in 1912.

Mr. Gamble Latrobe, recently appointed General Superintendent of the Philadelphia, Baltimore & Washington R.R. (Pennsylvania System) was born in Baltimore, Md., in 1866. He entered the service of the Pennsylvania in 1887 as levelman on construction work. The next year he resigned and entered the service of the Philadelphia & Reading Ry., but returned to the Pennsylvania in 1889, and was appointed Assistant Supervisor in 1890. In 1895 he was made Division Engineer of the Baltimore division, and in 1908 was appointed Acting General Agent and Superintendent, at Baltimore. Later in the same year he was made General Agent of the Philadelphia, Baltimore & Washington and the Northern Central Ry., and Superintendent of the Baltimore division of the Northern Central, which positions he has occupied until his present appointment.

Mr. Charles S. Krick, Acting General Superintendent of the New Jersey division of the Pennsylvania R.R., has been made General Superintendent of that division. He was born in Reading, Penn., in 1866, and is a graduate of Lafayette College (Class of 1887). After graduation Mr. Krick was employed as rodman in the assistant engineer's office of the Schuylkill division of the Pennsylvania. In 1903 he was appointed Assistant Engineer of the Eastern and Susquehanna divisions and was transferred to a similar position on the Philadelphia Terminal division during that same year. Three years later he was made Principal Assistant Engineer of the Philadelphia, Baltimore & Washington R.R. (Pennsylvania System). In 1912 he was promoted to Superintendent of the New York Terminal division, and when the Hudson and New York Terminal divisions were combined to form the Manhattan division, he was appointed Superintendent of that division. He was transferred to the Philadelphia Terminal division, in the same capacity, in 1914, and appointed Acting General Superintendent of the New Jersey division on Nov. 6, 1915.

Mr. Elisha Lee, General Superintendent of the Philadelphia, Baltimore & Washington R.R. (Pennsylvania System) has been promoted to the newly created office of Assistant General Manager of the Pennsylvania Lines East of Pittsburgh. He was born in Chicago, in 1870, and graduated from the Massachusetts Institute of Technology in 1892. The same year he entered the service of the Pennsylvania R.R. as rodman in the office of the Division Engineer of the Tyrone division. In 1903 Mr. Lee was appointed Assistant Engineer in the Maintenance-of-Way Department, and was advanced in 1907 to the position of Principal Assistant Engineer on the Philadelphia, Baltimore & Washington. In 1909 he was made Superintendent of the New York, Philadelphia & Norfolk R.R. (Pennsylvania System) and in 1911 appointed Assistant to the General Manager of the Pennsylvania Lines East of Pittsburgh and Erie. He was made General Superintendent of the Philadelphia, Baltimore & Washington in 1914. From 1912 to 1914 Mr. Lee served in the capacity of Chairman of the Conference Committee of Managers of the Eastern Railroads of the United States.

Mr. E. B. Ellicott, Fel. Am. Inst. E. E., has resigned as Chief Electrical Engineer of the Sanitary District of Chicago. He expects to devote considerable of his time to his ranch in Idaho and engage in consulting engineering in Salt Lake City. In 1885 Mr. Ellicott became connected with the Concordia (Kan.) Electric Light Co. In 1887 he was engineer and electrician for the Salina (Kan.) Gas and Electric Co., and the next year returned to Concordia as Superintendent of that plant. He entered the Western Electric Co., in 1890, and the following year was transferred by that company to Urbana, Ohio, in charge of the Urbana Electric Light Co. He was made Assistant Superintendent of Construction of the Western Electric Co. in 1892, which position he held until 1897, when he was appointed City Electrician of Chicago. He was granted a leave of absence in 1913, and as Chief Mechanical and Electrical Engineer of the Louisiana Purchase Exposition at St. Louis, designed and superintended the installation of a large part of the steam and electrical equipment of the Exposition. In 1905 he resigned as City Electrician of Chicago and was appointed Electrical Engineer of the Sanitary District.

OBITUARY

Willard T. Hough, Civil Engineer, Brooklyn, N. Y., died at Patchogue, N. Y., on May 8. He was 37 years of age.

Joseph J. Duffy, contractor, of Chicago, died on May 3, at the age of 56. He had handled a number of large contracts for the public works of Chicago.

James M. Mack, of the Mack Paving Co., Philadelphia, Penn., died suddenly at his home in that city on May 18. He had been in the contracting business since 1900.

Charles L. Negley, Engineer in the United States Forest Service, committed suicide at Portland, Ore., on Apr. 28. From a note which he left it is thought that he was despondent from ill health. Mr. Negley was a graduate of Cornell University and had been living in Portland about two years. He was 25 years old.

R. Mervin Lewis, Civil Engineer, killed himself during a fit of despondency at the home of a friend in Media, Penn., on May 10. He was Civil Engineer on the Media division of the Pittsburgh, Baltimore & Washington R.R. for five years until it was made part of the Maryland division recently. He was one of the officials sent to Wilmington, Del. His home was in Carlisle, Penn.

Frederick H. Meyers, Civil Engineer on the New York City Board of Water Supply, died at his home in Richmond Hill, N. Y., on May 21, at 45 years of age. Mr. Meyers was born in Allegheny County, Pennsylvania, and had lived in New York City and vicinity for several years. He was for a time engaged in the construction work on the northern aqueduct division of the Catskill Aqueduct.

Robert H. Ashworth, Civil Engineer, died at his home in Miami, Fla., on May 1. Mr. Ashworth had lived in Miami for about three years, previous to which he had been in the West engaged, with his son Frank K. Ashworth, on a number of projects, including the Colorado Springs water-supply and extensive irrigation works in Colorado and other Western states. The firm of Ashworth & Ashworth was first formed in Miami, but upon the declining health of Mr. Ashworth, his son made other business connections.

ENGINEERING SOCIETIES

AMERICAN IRON AND STEEL INSTITUTE.
May 26-27. General meeting in New York City. Secy., J. T. McCleary, 61 Broadway, New York City.

NATIONAL CONFERENCE ON CITY PLANNING.
June 5-7. Conference in Cleveland. Secy., Flavel Shurtleff, 19 Congress St., Boston, Mass.

AMERICAN WATER-WORKS ASSOCIATION.
June 5-9. Convention in New York City. Secy., J. M. Diven, 47 State St., Troy, N. Y.

SOCIETY OF AUTOMOBILE ENGINEERS.
June 12-16. Summer meeting (cruise on Lake Huron and Georgian Bay). Secy., Coker F. Clarkson, 29 W. 39th St., New York City.

MASTER CAR BUILDERS' ASSOCIATION.
June 14-16. Annual meeting, Atlantic City, N. J. Secy., Jos. W. Taylor, Karpen Bldg., Chicago.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 14-17. Eighth semiannual meeting. Cleveland. Secy., I. C. Olsen, Cooper Union, New York City.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.
June 14-21. Convention in Atlantic City. Secy., J. D. Conway, 2136 Oliver Bldg., Pittsburgh.

SOCIETY OF RAILWAY CLUB SECRETARIES.
June 16-17. Annual meeting in Atlantic City. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN RAILWAY MASTER MECHANICS ASSOCIATION.
June 19-21. Annual meeting, Atlantic City, N. J. Secy., Jos. W. Taylor, Karpen Bldg., Chicago.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
June 19-22. Annual meeting in Charlottesville, Va. Secy., F. L. Bishop, University of Pittsburgh, Pittsburgh.

TRI-STATE WATER AND LIGHT ASSOCIATION OF THE CAROLINAS AND GEORGIA.
June 21-23. Annual convention at Isle of Pines, S. C. Secy., W. F. Stieglitz, Columbia, S. C.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
June 22-23. Meeting at Cleveland. Secy., Frank E. Sanborn, Ohio State University, Columbus, Ohio.

NATIONAL GAS-ENGINE ASSOCIATION.
June 27-29. Annual convention in Chicago. Secy., H. R. Brate, Lakemont, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 27-30. Annual meeting in Pittsburgh. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-30. Annual meeting in Atlantic City. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Penn.

The Washington State Road-Builders Institute held its first annual meeting last week on the campus of the University of Washington.

The American Electric Railway Association has announced that its 1916 annual convention will be held in Atlantic City, N. J., Oct. 9 to 13.

The Eighth National Conference on City Planning will be held at Cleveland, June 5 to 7. There will be six conference sessions at which the several phases of city planning will be discussed. There will also be a business session at 4:30 p.m., June 7, and a banquet on the evening of that day.

The National Association of Manufacturers held its 21st annual convention at the Waldorf-Astoria, New York City, May 15 to 17. Monday was devoted to the regular business of the organization, while Tuesday evening was given over to a foreign-trade round-table discussion. The legislative situation as affecting industries was discussed on Wednesday and the banquet was held in the evening, John Hays Hammond being one of the speakers.

The American Road-Builders' Association has scheduled its 14th annual convention, to be known as the Seventh American Good Roads Congress and the Eighth National Good Roads Show, for the week beginning Feb. 5, 1917, in Mechanics' Hall, Boston, Mass. This decision was reached by the board of directors at a recent meeting in New York City. The last time the association held its convention in New England was in 1904 at Hartford, Conn. The headquarters of the association are at 150 Nassau St., New York City.

The Brooklyn Engineers' Club will hold its second annual moonlight excursion on the Steamer "Mandalay" on June 15. The final inspection trip for the season will take place earlier, on Saturday, June 3, when the club in conjunction with the Municipal Engineers of the City of New York will visit the fortifications and Proving Ground at Sandy Hook, N. J. A special train will leave from the foot of Liberty St., New York City (C. R.R. of N. J.) at 12:30 p.m. Those desiring to take advantage of this opportunity should notify the secretary, Joseph Strachan, 117 Remsen St., Brooklyn, N. Y.

Appliances and Materials

Granite-Finish Terra Cotta

A new terra cotta building tile with a texture and general appearance of granite is being made by the Federal Terra Cotta Co., of New York City. The lower four stories of the new Printing Crafts Building, at 34th St. and Eighth Ave., New York City, are finished in this material.

* * *

Small Motor-Driven Humidifier

For service in rooms where a moist atmosphere is desired a small motor-driven mechanical humidifier is being made by the Normalair Co., Winston-Salem, N. C. Each unit comprises a disk and fan on the motor shaft; water flows from a regulating chamber to the center of the disk and is thrown against a copper grid around the circumference. The water is finely divided by impact, and the fan blows out the floating particles. The heavier particles drain down into a drip pan. The disk is 16 in. in diameter, and one unit will humidify, for instance, about 20,000 cu.ft. of textile-mill room.

* * *

Lusterless Wood-Finishing Coat

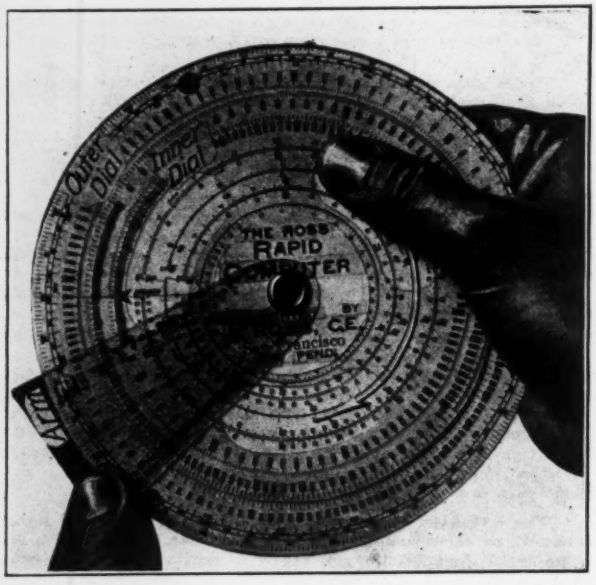
Under the trade name "Wonder Lac" a lusterless finish for stained wood is being made by the Bridgeport Wood Finishing Co., of New Milford, Conn. The new material has been compounded so as to be colorless and not to give any appearance of body—in response to a demand for a dampproof protecting coat which would not change the tone of stains or emphasize the finish.

* * *

New Circular Computer

A new circular-scale computing device has been devised by Louis Ross, of San Francisco, and is being made by the Computer Manufacturing Co., 25 California St., in that city. It has been aimed to secure a simple device handling a wider range of problems with fewer movements than possible with the slide rule. The computer is shown in the accompanying illustration. It is made in two sizes: 6-in. diameter, selling for $4.50, and 8-in. diameter, selling at $7.50. The instrument is made of weather- and wear-proof celluloid; it is flexible and has no glass parts; unequal shrinkage of parts, it is claimed, does not affect its accuracy. The two sizes correspond to the lower scales of a straight slide-rule, 16 and 21 in.

The scales are arranged to solve expressions like $a \times b \times c$, or $a \div b \times c$, and ordinary trigonometric calculations, with



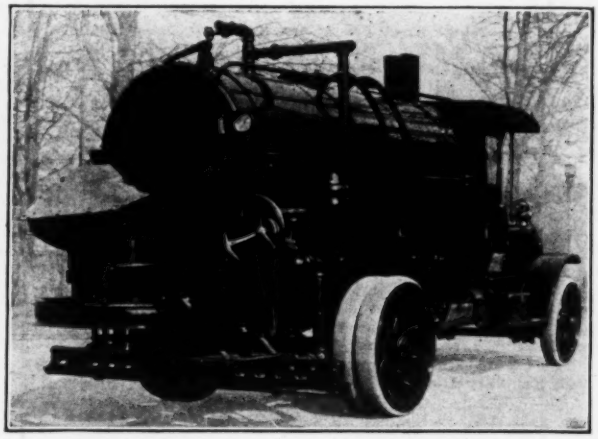
ROSS "RAPID COMPUTER"

one setting of the dial. Beginning with the outermost, the scales on the outside dial are: (1) Degrees, 0° to 360°, for measuring angles; (2) Radians, 0 to 2 (6.283), for circular measure; (3) A scale of equal parts, 0 to 1,000, to read logarithms; (4) Scale N, for setting the first number and reading the answer. The scales on the inner dial are: (5) Scale M, like scale N, but numbered reversely, to set multiplier; (6) Scale D, like scale N, to set divisor; (7) Sines and cosecants, 6° to 90°; consines and secants, 0° to 84°; (8) Sines and cosecants, tangents and cotangents, 37′ to 6°; Cosines and secants, tangents and cotangents, 84° to 89° 23′; (9) Tangents and cotangents, 6° to 84°; (10) A scale of squares; (11) A scale of cubes. The conventional method of graduations has been replaced by a system of three and four digit numbers to facilitate direct reading. Each turn of either dial or reading arm performs an effective computing step—there are no blank movements. Full directions and detailed examples are furnished with each instrument.

* * *

Road-Maintenance Truck

The combination road-maintenance and construction motor truck shown in the accompanying view has just been made by the White Co., of Cleveland, for the Department of Streets and Sewers of the City of St. Louis. Similar vehicles are



THE WHITE ROAD-MAINTENANCE TRUCK

being made for the Cities of San Francisco, Indianapolis, Fond du Lac, Wis., Lexington, Ky., for Onondaga County, N. Y., the Roads Preserving Co., of Cincinnati, and the Atlanta, Ga., Gas Light Co. The truck is the development of the same company's "good roads" truck; it is made in two sizes—one has an 800-gal. tank on a 3-ton chassis, and the other a 1,000-gal. tank on a 5-ton chassis. It is aimed to eliminate need of separate trucks for flushing and sprinkling streets, for applying light and heavy oil, or for applying hot liquid asphalt to road metal with penetrating pressures. When the road work is not pressing the iron tank can be lifted off and an ordinary body substituted.

A rotary pump, driven by a lay shaft from the rear of the truck transmission case and having 13-ft. lift, is used to fill the tank, to sprinkle or flush with water, to circulate road oils during heating, or to deliver oil to a set of 16 spreading nozzles in the rear. These nozzles spread uniformly over a strip of road 8 ft. 6 in. wide. Three sets are furnished for different work. Each throws a fan-like stream, one stream overlapping the other. If desired, the nozzles can be moved to the right or left of the center a distance of two feet. The nozzles and pump pressure are regulated by a man from a small seat in the rear and on the right side. This man can communicate with the driver of the truck, while the truck is in motion, by means of a double bell system. After the oil has been shut off the pump carries the quantity remaining in the pipes back into the tank and an automatic drip-trough falls, preventing any of the oil on the mouth of the nozzles from dripping to the road. This is particularly useful in passing over street crossings. After the truck has been used for oiling, the tank can be quickly cleaned by using the pump to circulate kerosene through it. Small tanks of kerosene and gasoline are located on the left side of the truck.

* * *

Hand-Thrown Derailing Block

A new hand-thrown derailing block has been put out by the Hobart-Allfree Co., Chicago. The device comprises a strong cast base and a pivoted arm with derailing head swinging over around the rail head. The base is reversible, and there are pivot-bolt holes at different levels so that the same block can be used with different sizes of rail. Registering padlock holes on base and arm permit locking in either clear or derailing position.

Engineering News

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Advertising Index, Last Page

TECHNICAL ROOM
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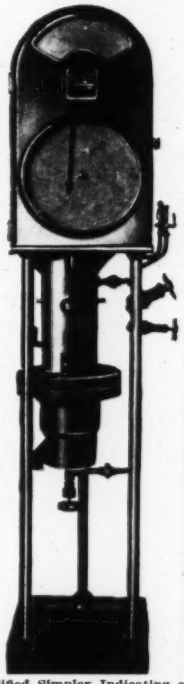
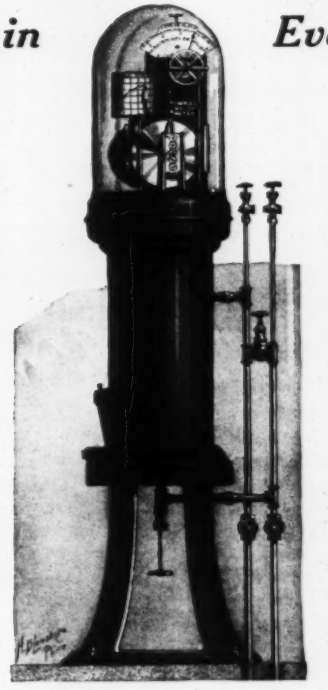
SIMPLEX

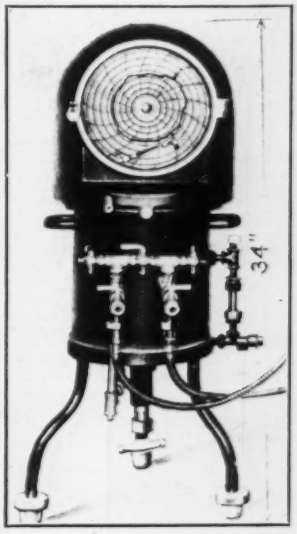
Accuracy in Every Service—



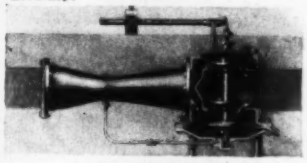
A simplified Simplex Indicating and Recording Meter—low in price but high in accuracy.



Standard Simplex Indicating and Recording Meter—99% accuracy on high or low velocities—suitable for Venturi or Pitot Tube Measurement.



Simplex Portable Pitot Tube Recorders. Light in weight—accuracy retained—invaluable on Water Waste Surveys.

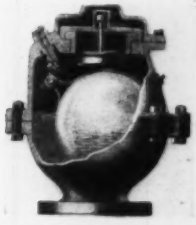


Simplex Rate Controller.

In flow measuring, recording, and controlling, Simplex Meters and other Apparatus stand pre-eminently to the front as devices of extreme accuracy. .

Simplex accuracy works hand in hand with simplified construction and minimization of working parts.

The latest Simplex Literature gives interesting details on our many products. Bulletins upon apparatus in which you are interested gladly sent on request.

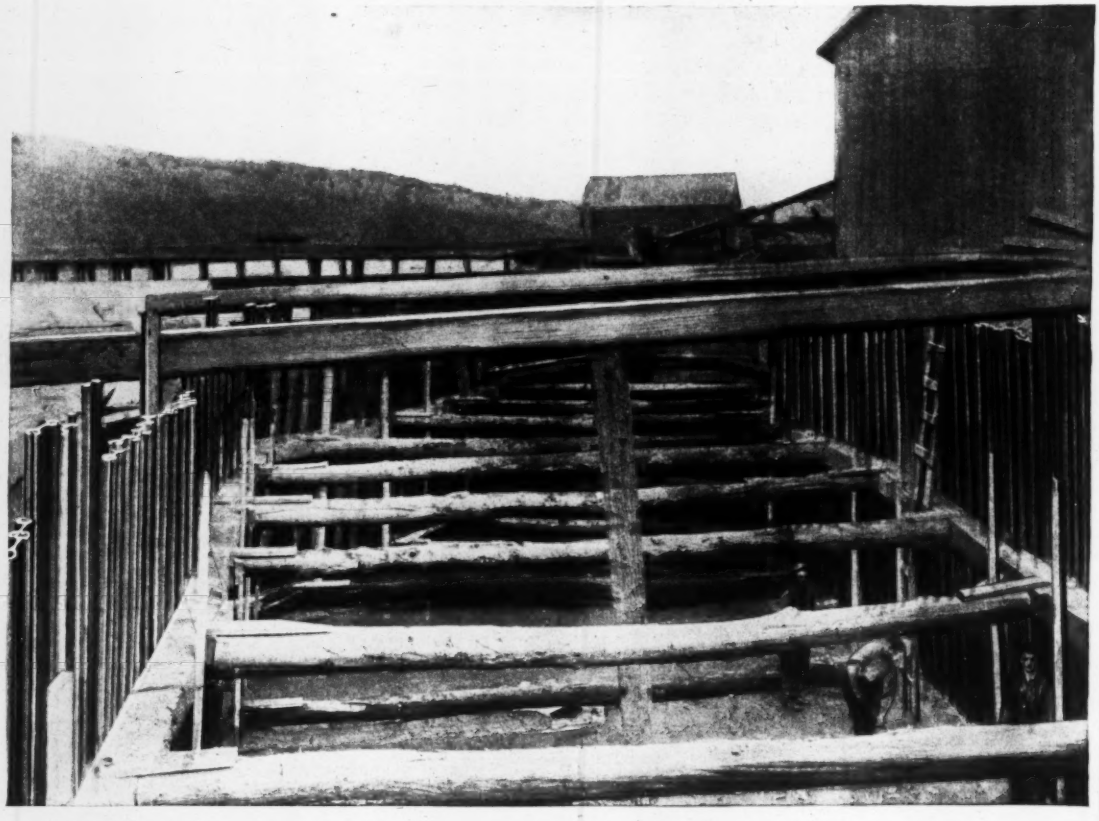


Simplex Combined Air and Poppet Valve.

Simplex Valve & Meter Company, 112 N. Broad Street **Philadelphia, Penna.**

New England Representative—Geo. W. Stetson, 141 Milk St., Boston, Mass. Pacific Coast Representatives—Water Works Supply Co., San Francisco and Los Angeles. Canadian Representatives—Francis Hankin & Co., Montreal, Toronto and Vancouver.

Also manufacturers of Controlling Altitude Valves for Reservoirs, Standpipes and Railroad Water Tubes; V-Notch Weirs, Loss of Head and Rate of Flow Gauges for Filters; Head and Fall Indicating and Recording Gauges for Water Wheel Plants.



"We would not care to consider cofferdam work of any consequence without using Lackawanna Steel Sheet Piling"

The contractors who said this, Chesley, Earl & Heimbach of Buffalo, N. Y., have done much work in various places on the New York State Barge Canal and used all sorts of sheeting so they know what they are talking about.

One of their canal installations at Watkins, N. Y. is shown above. At this particular location, steel sheet piling of the Lackawanna $\frac{3}{8}$-in. Straight-Web Section exhibits its characteristic watertightness. The men shown are standing on dry bottom. Only a small pulsometer pump was required here to keep the dam dry, and at night the steel sheet piling had to be tapped to let in enough water to feed the pulsometer and keep it from stopping.

These contractors are specially enthusiastic about the watertightness of the Lackawanna Interlock, and state that for its purpose, nothing else equals Lackawanna Steel Sheet Piling.

If interested in steel sheet piling construction, send for our literature, and take advantage of our free engineering advice.

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Engineering News

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Chicago Has New Shop Plant for All Public Works

By C. C. Saner*

SYNOPSIS—The City of Chicago has consolidated the shops of its water, sewer, fire, police and other service departments and built a modern industrial plant having machine, carpenter and paint shops, foundry, administration building, garage, storehouse and storage yards. The manufacture of new water-works supplies forms a large item in the plant's work. Layout of the new works and general equipment of the several shops are described.

As the City of Chicago has annexed territory from time to time, various local fire, police, sewer and water departments have been amalgamated with the existing city departments, and these last have grown also with the increase in population of the original city. A greater and greater amount of repair and construction work has had to be done, and increasing quantities of supplies have had to be stored for the various public departments. The departments have established shops and warehouses from time to time as their individual needs have demanded, but these have been scattered about the city in any building the city happened to own or could conveniently rent. The structures have been old, poorly lighted and insanitary, and showed serious fire hazards. Valuable patterns, like those for pumping-engine and bridge-machinery parts, were stored where, if a fire had once started, it could not have been stopped before the loss would have been irreparable. No attempt was made until recently to standardize the great amount of supplies bought by the various departments.

Such inefficiency in public works is not due in any large measure to graft and corruption. The city has only been in the same position as some of the country's great industries. In order to give service to their customers at all they have had to perform many operations in an inefficient manner. After the service requirements have been met, the industries have built modern plants and stopped the leaks in manufacturing processes. Where the growth of a city like Chicago has been rapid, the problem of government has been difficult. Many times efficiency has had to be entirely disregarded in order to maintain public service. Bringing the service in new territory up to the older standards has required time, effort and expense. The assembling of the shops and warehouses of all the public-works departments in a modern industrial plant is but one of the final steps of the development of the government.

FIG. 1. GENERAL VIEW OF CHICAGO MUNICIPAL SHOPS UNDER CONSTRUCTION
From left to right—Machine shop, foundry, carpenter shop and warehouse

In 1913 the city had the service problem in hand well enough to start a comprehensive plan for the consolidation of the various shops and warehouses. Thirty acres of land at 31st St. and Sacramento Ave. was purchased for the construction of a modern plant.

A careful study was made of the shops of the water, police and fire departments, of the various warehouses and of the records stored in the vaults of the City Hall. After these surveys had been completed, the general plan and size of buildings were determined and construction work was started, in the spring of 1914.

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As the city manufactures all its fire hydrants and valves up to 12 in. in diameter, the plan had to be so made that the work would progress in an orderly manner from the pattern shop through the foundry and machine shop to the warehouse and storage yards. Provision had to be made to store all patterns, supplies of all kinds and public records. The machine shop had to be erected so as not only to manufacture hydrants and valves, but also to repair all kinds of pumping machinery, fire and police equipment and construction machinery. Fig. 2 shows the general layout of the complete plant, as finally made.

The foundry was completed and placed in operation in August, 1915, and is now supplying all castings for the city except straight cast-iron pipe. All manhole curbs and covers, special water-pipe castings, hydrant and valve castings are made here. The castings are made and delivered at market prices, and it may be safely stated that the castings are of a better quality than can be bought. Inspection of materials is maintained here the same as it would be maintained on an outside con-

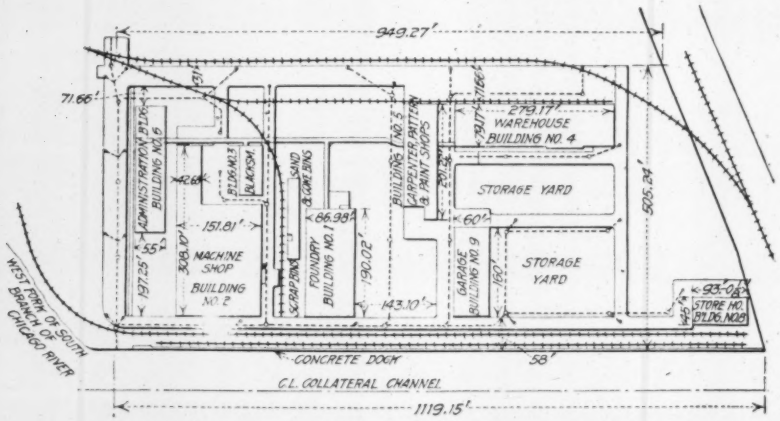

FIG. 2. GENERAL PLAN OF NEW CHICAGO MUNICIPAL SHOPS

tract, except that there is not a continual disagreement between the inspectors and the contractors. Fig. 3 shows an interior view of the foundry before operation was started. The iron-molding room is equipped with two traveling cranes. One is of 5-ton capacity, and the other of 10 tons with a 3-ton auxiliary hoist. The flask yard and the iron yard each have a traveling crane of 5 tons' capacity. The cupola is of 10-ton capacity. No device for the most efficient operation of a foundry has been omitted, and the operating costs bear out the wisdom of the policy.

The machine and blacksmith shops were placed in operation in May, 1916, and results of operation in the new plant as compared with the old will not be available for some time. The machine shop consists of the main shop and a two-story north and south wing. The blacksmith shop is an extension of the south wing with one bay omitted. The north wing is extended the same number of bays as the south wing; and when more room is required, the space between will be roofed over and the omitted bay built in, giving a shop 308 ft. long. The south wing of the machine shop is assigned to the small machine tools for manufacturing hydrants and valves and to the toolroom. The north bay is assigned to the repair of fire and police equipment of all kinds, a supply room and an assembly room for hydrants and valves. The main shop contains the large machine tools and has available room for concrete mixers, road rollers, ditching machines, etc., undergoing repairs. The second floor of the south wing is assigned to the water-meter repairing and testing division. The second floor of the north bay is unassigned as yet.

The main shop is equipped with a 25-ton traveling crane having a 5-ton auxiliary hoist. Jib cranes are placed at convenient locations for handling castings to the machines. The blacksmith shop is equipped with nine down-draft forges, a steam and power hammer and a jib crane operating in full circle. The foundry, machine and blacksmith shops are of steel construction with brick walls, steel window and door frames and wire-glass windows.

The carpenter-, paint- and pattern-shop building and the warehouse are of the same type of construction. Both have four stories and a basement and are on caisson foundations. The frame is of reinforced concrete with brick curtain walls, steel window and door frames and wire-glass windows. Both buildings are equipped throughout with automatic sprinklers. The carpenter-, paint- and pattern-shop building will contain also steam fitters', sheet-metal workers' and harness shops and the pattern-storage rooms. The warehouse floors are unassigned; supplies and records will be stored as they are received.

The administration building, now under construction, will contain the offices for the general supervision of the plant, an electric-power transformer room, a dining room and kitchen, all on the main floor, and testing laboratories on the second floor.

The power house will be inside the grounds of the House of Correction, just across the west fork of the south branch of the river. All piping and wires will be carried through tunnels to the various buildings. The power house will be operated with convict labor, so that power will be furnished at less than 1c. per kw.-hr., and heat will be at the same relative cost. This power house will furnish, in addition, heat, light and power to the new city contagious-disease hospital, which is located on the east end of the new property, and to the buildings of the House of Correction.

A garage with a capacity of 40 machines has been constructed west of the warehouse. Eighteen trucks are now used by the Division of Pipe, Yards and Stores, all of which will operate from this garage. Under the east end of the garage a basement has been constructed in which are two 10,000-gal. oil tanks for storing engine and cylinder oil, and smaller tanks for other lubricating oils, while buried in the ground just outside are a 12,000-gal. tank for gasoline, a 1,000-gal. tank for kerosene and a 500-gal. tank for turpentine. These large tanks have pipe lines running to the switch track at the west of the garage for unloading tank-cars.

The yard for storing special castings will be paved with concrete on the same grade as the roads, no curb extending above the pavements. This provision is made to allow electric elevating-platform trucks to run into

the yard with castings and place them. Castings will not be removed from the platforms on which they are transported, but will remain on them until they are removed for shipment from the yard.

Derricks will not be provided in the special-casting yard, as it is planned to gather all materials for truck delivery on a loading platform on the west side of the warehouse. By collecting all materials for truck delivery in this way, trucks will be able to load and leave the plant in a minimum amount of time.

FIG. 3. IN THE CHICAGO CITY FOUNDRY

A concrete dock has been constructed along the collateral channel of the drainage canal, west of the plant. This dock will provide a way for fireboats, tugs, scows and other craft to lie adjacent to the shops for repairs.

FIG. 4. IN THE CHICAGO CITY MACHINE SHOP

All building has been done by day labor under the direct supervision of W. H. Dean, Assistant Engineer, working under H. W. Clausen, Engineer of Water-Works Construction. Plans were made by Myron B. Reynolds, Engineer of Water-Works Design. The general scheme was evolved under John Ericson, City Engineer; Henry Allen, Consulting Mechanical Engineer; and H. S. Baker, Assistant City Engineer. The plant is estimated to cost, when complete, $1,750,000.

City-Manager Government at Phoenix Undergoes Test

EDITORIAL CORRESPONDENCE

The city-manager form of government has, in effect, undergone and is undergoing a very severe test at Phœnix, Ariz., where it has been established for nearly two years. Phœnix seems to have gained a reputation for being a hot-bed of politics, and it is doubtful if any one but an outsider could get an unbiased view of what has taken place there. The controversy between the adherents of the former city manager and those of the present holder of that office has been very bitter, and without attempting to pass on the merits of either side, a plain relation of facts and events is enlightening to those who are interested in city-manager government—and what municipal engineer is not?

The people of Phœnix adopted a new charter in 1914, which was drawn for the express purpose of "entirely eliminating politics" from the management of the city. The legislative body is a commission of five, including a mayor—elected as such to meet the requirements of the state laws. The mayor is ex-officio chairman of the commission. He receives a salary of but $300 a year, with a contingent fund of $200. The commissioners receive $5 for each meeting attended, not to exceed $300 per year. The mayor and commissioners serve for two years, but there is an election each year, alternately, for two commissioners, and for two commissioners and the mayor. The election recently held was of the latter description, so that a majority of the commission was subject to change.

The mayor and commissioners are nominated through direct primaries. Any person may enter the contest whose petition contains enough signers to equal 3% of the number of voters for mayor at the most recent election. The important offices are the city manager, city auditor, city attorney, city clerk and city treasurer. There are the usual charter provisions for initiative, referendum and recall. All other city offices are filled by appointment.

Under the original charter provisions the city manager was appointed by the commission to hold office *until removed for cause* by the commission. His salary was fixed by the charter at $5,000 per annum. The city auditor and city magistrate were the only other officers appointed by the commission. Under the original charter provisions all minor officials were appointed independently by the city manager and removed at his pleasure. Subsequent changes in these provisions and the train of events which led to them will be considered in due course.

The first city manager was a competent civil engineer, a former employee of the United States Reclamation Service. He was a "native son." As a city manager he is alleged to have been a failure from the very start. That engineers who would be city managers may profit, a recital of some of these alleged shortcomings from the point of view of a layman is of interest. He is said to have lacked dignity, to have made himself too readily accessible to anyone and every one, to have spent much of his time in the open where he could not be found when wanted on important occasions, to have allowed too many liberties of his many friends and encroachments upon his time—in short he was perhaps too good natured and affable. Such are allegations of friends and opponents.

The city manager was soon out of harmony with the majority of the commission. Whether this was due to his economies and weeding out of unnecessary city employees, as it is understood are his claims, or whether it was due to other reasons is not within the province of the writer to decide; but since there was a lack of harmony it may be presumed that there was also a lack of tact.

Things went from bad to worse so far as the city administration was concerned, until, it is alleged, conditions were far less satisfactory than under old-time politics. The commission sought to remove the manager out of hand but found the charter in the way of such a course. At length charges of incompetency were brought and a public hearing held, at which the commission was both judge and accuser. The city manager was duly discharged as incompetent. He subsequently took his case to the courts and the lower court has upheld the action of the commission.

The people were aroused at the conditions described, and to prevent a repetition of such a controversy the city charter was amended, as provided for, by popular election. The only wonder is that the voters should have continued their faith in city-manager government, and that changes were not more radical. However, these changes were enough to seriously affect the powers of the city manager.

The changes in the powers of the city manager under the original and the amended charter provisions are shown in the following columns:

ORIGINAL PROVISIONS	AMENDED PROVISIONS
The manager shall have the general supervision and direction of the administrative operation of the city government; he shall supervise and direct the official conduct of all appointive city officers, except the auditor and city magistrate; he shall supervise the performance of all contracts made by any person for work done for the city, and in that behalf represent the city, except as it may be otherwise provided in this Charter; he shall make all purchases of materials or supplies for the city and see that the same are received as contracted for; he shall employ and discharge from time to time as occasion requires all employees of the city; he shall appoint all officers of the city, the appointment or election of whom are not otherwise provided for in this Charter, and may remove them when the interests of the city require.	Section 1. Subject to the control of the Commission, the manager shall have the general supervision and direction of the administrative operation of the city government; he shall supervise and direct the official conduct of all appointive city officers except the auditor, city attorney, city clerk, city treasurer and city magistrate; he shall supervise the performance of all contracts made by any person for work done for the city, and in that behalf represent the city except as it may be otherwise provided in this Charter; he shall make all purchases of materials or supplies for the city, subject to the provisions of this Charter, and see that the same are received as contracted for; he shall employ and discharge from time to time, as occasion requires, all employees of the city appointed by him, by and with the consent and approval of the Commission; he shall appoint all officers of the city, the appointment or election of whom is not otherwise provided for in this Charter, and may remove them when the interests of the city require. Section 2. It shall be his duty, as well as that of the mayor, to see that all of the ordinances of the city are enforced.

These changes place the manager under the specific "control" of the commission so far as general administrative work is concerned; they take from the manager the appointment of the city clerk, treasurer and attorney; they make the appointment and removal of "employees" subject to approval by the commission, but appear to leave the manager independent of the commission as regards those "officers" whom he has power to appoint. Other amendments make the manager subject to removal by a three-fifths vote of the commission, and makes the manager's salary subject to the commission, instead of being fixed in the charter.

The second (and present) city manager, appointed under the revised charter, is also an engineer by education and experience. He was for a number of years connected with the former city water-works company, had responsible charge of many of the water-works improvements and is thoroughly familiar with the business management of a public utility. Fortunately for city-manager government in Phœnix his first year of the city administration has been very successful.

The city tax rate, which formerly ranged from $1 to $1.30, was this year reduced to 85c., and yet the administration will complete the fiscal year with a surplus of over $50,000. This reduction in tax rate is all the more noteworthy because there was a revenue loss of $26,000 from liquor licenses, due to state prohibition, and $28,000 loss from occupational taxes, which were abolished.

There was also a loss of revenue from a dropping off of police court fines, and there was a reduction in the assessed valuation of property to the extent of $2,000,000. Had conditions remained the same the tax rate would have been reduced to 60c.

The amount of public improvement work has remained about the same, but many economies have been effected in its performance. To mention but one there is the abolition of the city corral and the substitution of motor-driven vehicles throughout the city departments. The city corral was a well established institution for petty grafting—the renting of wornout and skinny horses to the city to be cared for and fattened at public expense. Increased efficiency of the city fire department has reduced the annual fire loss from about $200,000 to less than $25,000.

The city manager has frankly acknowledged that it has been impossible to avoid politics entirely and that he is frequently hampered in the way of appointments by members of the commission. Nevertheless he has tactfully insisted on the efficient administration of the various bureaus under him, of which the results speak for themselves. For instance, he insisted on the employment of a competent city engineer and the doubling of the salary of that office so that a competent engineer would accept it. The present city manager has no serious fault to find with the charter requirements which make him more dependent on the will of the commission. He truly says that conditions are the same as they are in every business corporation and that if the manager is out of harmony with the majority of the commission or board of directors, or lacks its confidence, it is better for all concerned that he resign.

As previously noted, the city-manager form of government is just emerging from a crucial test. At the election of the first Tuesday in April a mayor and two commissioners were elected. The former mayor and one commissioner had been very antagonistic to the city manager and in announcing his candidacy for reëlection this mayor published broadcast the statement that if he and his choice of new commissioners were elected he would clean out the present city administration and reduce the city

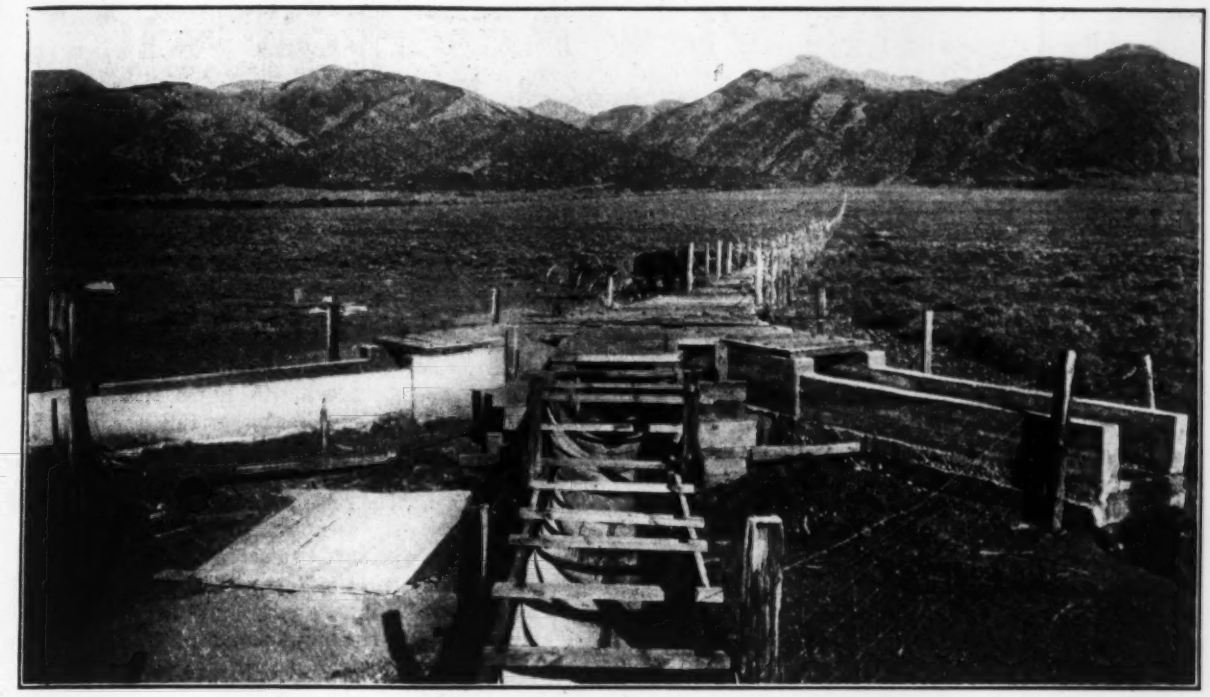

FIG. 1. THREE-WAY CONCRETE DIVERSION BOX AND METAL FLUME 13,000 FT. LONG

manager's salary from $5,000 to $2,500 per annum. Fortunately he was defeated, and the chances are that the city-manager form of government will triumph and be firmly established beyond the reach of irresponsible politicians before another election for a commission majority occurs.

There are those in Phœnix who claim that its experience with city-manager government has demonstrated its failure—that the office has become a plaything in politics and the manager forced to become a politician—but that has not yet been proved.—N. C. R.

Long Straight Steel Flume

What is claimed to be the largest section of straight metal flume in the world is shown by Fig. 1. The length of the flume on tangent from the diversion box in the foreground to the distant mountains is 13,000 ft., or 2¼ mi. This structure was recently completed by the Colorado Culvert and Flume Co., Pueblo, Colo., for a private irrigation company in the San Luis Valley, Colorado.

The entire flume, including the portion beyond the diversion box, is 3⅛ mi. long and has in that distance a total fall of 750 ft.; the maximum grade is 7½%. The flume carries 70 sec.-ft. of water, and the velocity runs as high as 30 ft. per sec. As the flume passes through a sheep-grazing country, it is fenced the entire distance.

The three-way diversion box is also a somewhat unusual structure in flume work. It is constructed of reinforced concrete with 6-in. walls. This box and the other irrigation structures were built without engineering service, except that donated by the flume company.

The flume is of a patented type known as the "No-Lap" joint flume. A sketch of this joint is shown in Fig. 2. Each end of a flume plate has a semicylindrical head into which one of the double ribs or convex heads of an inside clamp or semicircular hoop fits. A similar clamp or half-hoop with concave cross-section fits over the ends of the flume plates; the carrier rod, tightened

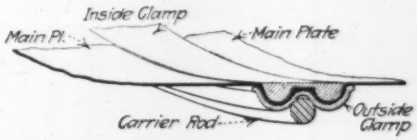

FIG. 2. DETAIL OF JOINTS IN FLUME

by nuts on the carrier beams or crossties, binds the whole together. The joints are spaced 35½ in. c. to c.

The flume illustrated is 3 ft. 10 in. in diameter and weighs complete about 16 lb. per lin.ft. The same type of flume is made in sizes up to 13½ ft. in diameter.

The foregoing information was obtained from L. R. Shallenberger, Manager of the Colorado Culvert and Flume Co.

Paving in Texas Is Hampered by the state homestead law, which prohibits a lien on property owned as a homestead for any debt whatsoever. A paving contractor in this state has to make individual contracts with each property owner whose property is affected by the laying of the pavement, for which the city authorities have awarded him the contract. He also has to carefully examine the title to every piece of property in order to give due consideration to the homestead law; he has to maintain a collection agency for the collection of the partial payments (often spread out over ten to twenty years) and has further to carry an organization of highly qualified officials and lawyers. All this adds from 10 to 20c. per square yard to the cost of the pavement. Naturally small contractors are unable to enter into competition with the large, well-organized and financially strong paving companies of national scope. Owing, however, to the many legal complications, it is doubtful, even with an absence of all real competition, if these paving companies succeed in making extraordinary profits. If the local representatives of some of these large paving companies express their true opinion of the situation they would much prefer to do business as in other states, where there are no such legal handicaps for the small contractor.

Lining Hill View Reservoir with Concrete and Riprap

By Arthur W. Tidd*

SYNOPSIS—Methods used in lining equalizing reservoir for new Catskill water-supply of New York City. Lining consists of lower level concrete paving and upper level stone paving and riprap. Methods of placing earth embankment described in "Engineering News," Sept. 9, 1915, p. 500.

Hill View Reservoir, on the line of the aqueduct for the new Catskill water-supply for New York City, is situated just north of the northern limit of the City of New York. It is an equalizing reservoir, its 900,000,000 gal. of water acting to modify the effect of the hourly fluctuation in the rate of draft, and correspondingly of inflow, and to maintain a nearly uniform head on the distribution system throughout the city. The reservoir is of the earth-embankment type, roughly rectangular, about 3,000 ft. long and 1,500 ft. wide; depth of water 36½ ft., capacity about 900,000,000 gal., area of water surface about 90 acres. The entire dependence for water-tightness is placed on the earth embankment, no core wall or cutoff wall being provided. The bottom of the reservoir and the lower half of the inside slope are faced with concrete, for purposes of cleanliness and with no intention of providing additional water-tightness. The upper half of the slope is faced with dry rubble paving and riprap. The formation at the site of the reservoir is a very hard-packed, dense glacial drift without stratification. No ledge rock was encountered. The material was well graded from coarse sand to rock flour and when in its original position, was impervious to water.

Placing Toe Wall and Berm Wall

The first work to be done on the concrete portion of the lining was the construction of the toe wall and berm wall. The toe wall is at the reservoir floor level and takes the thrust of the concrete slope lining. The berm wall is at the level of the berm and takes the thrust of the slope paving and riprap. The toe wall is about 7,400 ft. long and the berm wall about 7,700 ft. The first season both walls were built in alternate sections 16 ft. long with expansion joints every 48 ft. The expansion joints were formed by three ⅛-in. steel plates, three being used together, each thoroughly greased. By pulling out the center plate first, the other two were readily withdrawn. During the following winter it was found that the expansion joints in the berm wall allowed surface water to work through below grade instead of staying on the surface. The conditions were studied, and the design was modified to the extent of eliminating the expansion joints for the remainder of the work and also excavating for and casting a small cutoff block monolithic with the concrete on the berm at each expansion joint built the first season, whenever it was reached. Also, the construction method was changed by first excavating for and casting blocks 2 ft. long and of full section, 24 ft. apart on centers. The intermediate spaces were excavated and concreted after the blocks had set. This method was followed throughout the remainder of the work.

Preparation of Slope for Concrete Lining

The reservoir embankment was built up in 4-in. layers, each layer thoroughly rolled with 10-ton steam rollers. The embankment was built somewhat full on the slope and berm, so that when properly trimmed for placing the lining, material thoroughly compacted by the roller would be exposed. The slope for the concrete lining was uniformly 1 on 2; the berm was horizontal. The trimming was done with hand tools using mattocks for finishing, the material being cast to the foot of the slope for removal. Hubs 2 in. square were driven to finish line and grade (for trimming) at the edge of the berm and at the toe wall on lines 8 ft. apart and at right angles to the slope. The previously constructed berm wall provided the other necessary grade point on the berm. Intermediate points were set by string as needed. A low earth dam or a row of sandbags laid along the berm wall was often used to divert surface water from the slope above from the finished slope below, but some erosion was caused by the rain that landed beyond the berm, especially if the storm was of long duration. Wherever large gullies were formed by a concentrated flow, the contractor was given the option of filling them with concrete at the time of placing the lining or tamping them full of selected earth; both methods were used. The contractor trimmed as little area ahead of the concreting as possible in order to reduce the possibilities and amount of all erosion, as under the contract he was responsible for the extra quantities involved.

Placing the Concrete Slope Lining

The concrete slope lining was placed in alternate strips, 8 ft. wide, continuous from toe wall to berm wall, 3 or 4 strips usually being carried up at the same time (Fig. 3). Spruce timbers 4x9 in. were used for forms, spliced where necessary to make the form continuous up the slope, about 48 ft. When a form was moved, a gang of men lifted it bodily, walked up the slope far enough to clear the fresh concrete, then along the bank and finally down the slope again to the new position. The forms were set on the hubs used for trimming. The concrete was a 1:8 mix, using the regular 2-in. stone furnished for all concrete. It was delivered in bottom dumping buckets of 1⅓ cu.yd. capacity and handled into place by an electrically operated stiff-leg derrick traveling on tracks laid on the bottom of the reservoir along the foot of the slope (Fig. 2). For the first half of the work, the concrete was mixed in a 1½-cu.yd. Chicago cube mixer, but later by the 1½-cu.yd. Hains gravity mixer used for the bulk of the concrete work on the contract. It was essential that the quantity of water be carefully controlled, because if the batches were too wet, the whole mass would work down the slope, and if too dry, a great amount of tamping was required and the

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surface finish was unsatisfactory. The concrete was deposited directly on the prepared earth slope. Square-pointed shovels with extra long D-handles were used to spread the concrete and to finish the surface. No screeding was done, but the final shape was tested frequently with a wooden templet. No trouble was experienced in forming the raised portion along the joints. The concrete was sprinkled with a hose for about two weeks after laying. When the intermediate slabs were being laid, a flat ladder made of 7/8-in. boards placed on the previously finished concrete was of value in providing a secure foothold for the workmen and protecting the concrete. Seven drainage holes along each joint were formed by round wooden pins tapering from 2½ in. to 1½ in. in the thickness of the slab. They were designed to relieve the hydrostatic pressure that might be developed when the extreme south end. The thickness of the lining was uniformly 6 in. Excavating was done by steam shovel to within a reasonable distance of the concrete subgrade, the remaining material being removed by lighter tools and more easily controlled methods. Any steam-shovel excavation below grade was ordered filled with concrete at the contractor's expense. No refilling with earth was permitted, and all depressions were filled with concrete as the lining progressed in order to insure a suitable foundation for piers in case the reservoir should subsequently be covered. After the steam-shovel cut was made, a heavy spike-tooth harrow drawn by horses and supplemented by men with picks was used to loosen the earth. A four-horse road scraper scraped the loosened material into windrows, making the area quickly available for the harrow again. The windrows were taken up by wheeled

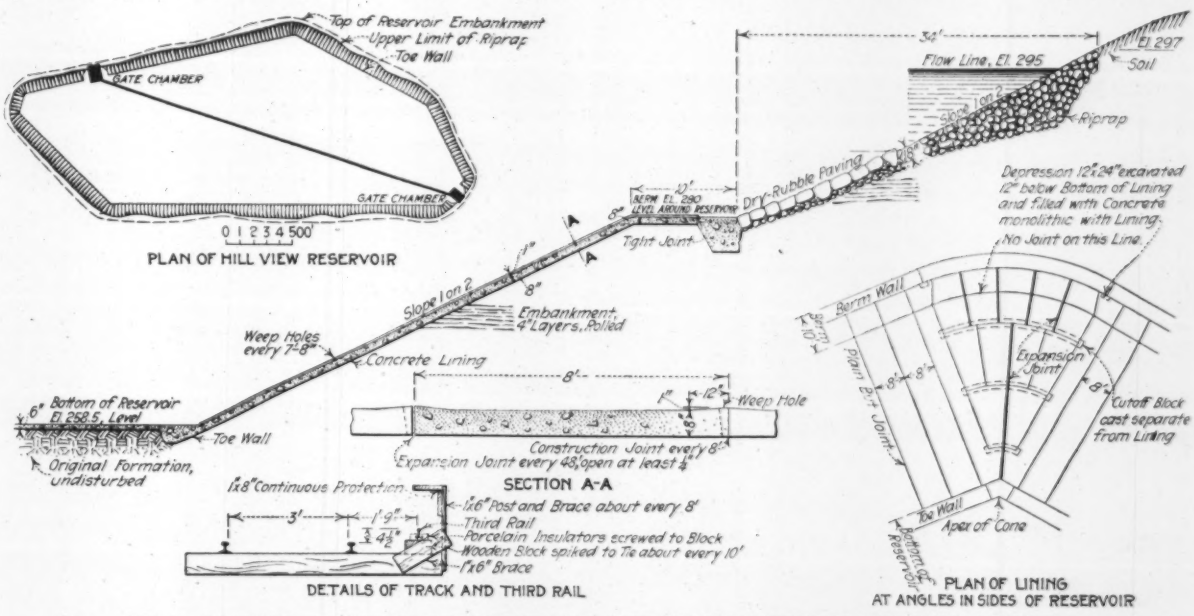


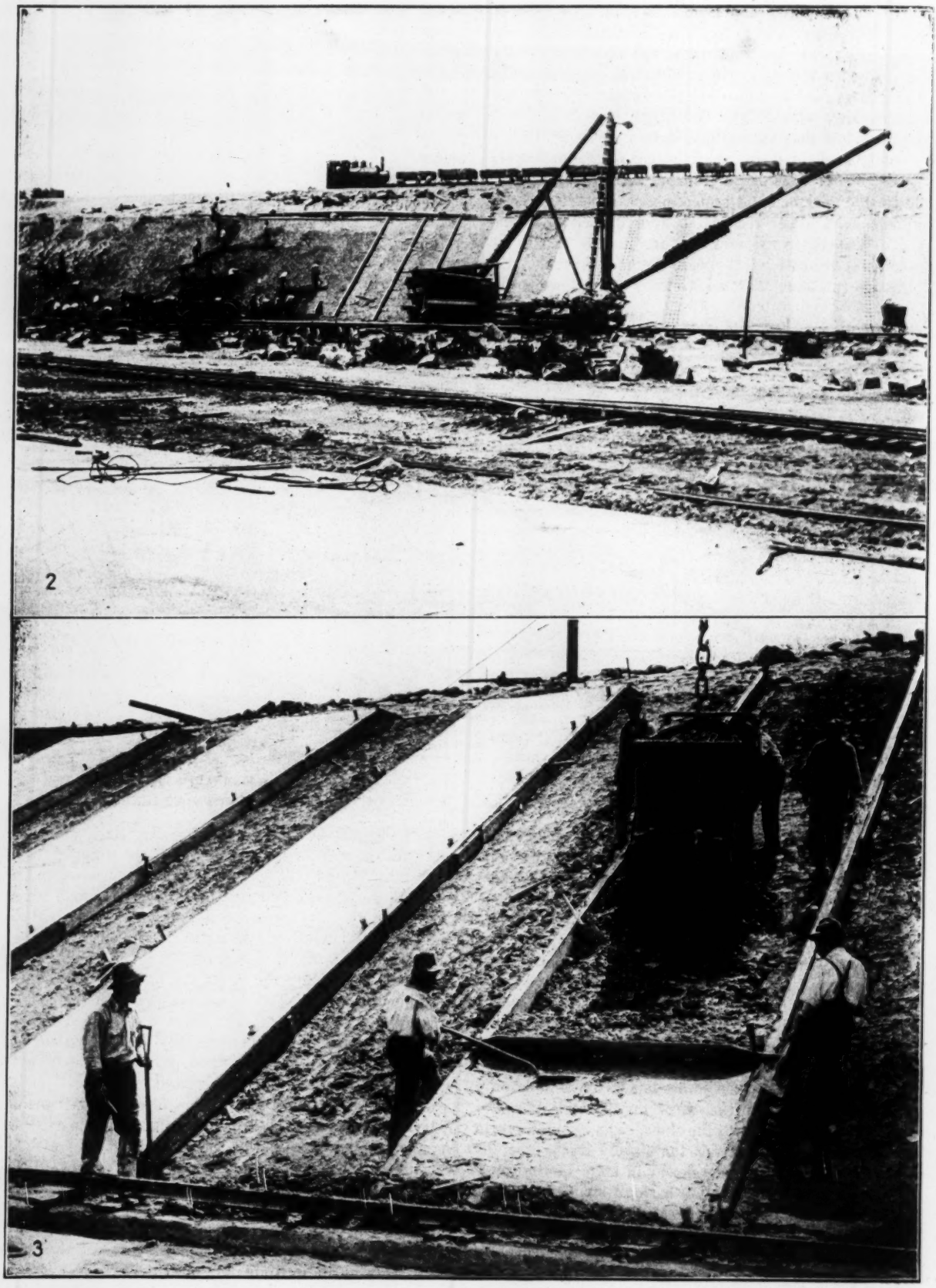
FIG. 1. PLAN OF HILL VIEW RESERVOIR AND DETAILS OF CONCRETE AND RIPRAP LINING

reservoir was lowered. The raised portion along each joint was to prevent surface water flowing down the slope from entering the joint and scouring out the subgrade. Every sixth joint (48 ft.) was an expansion joint about ¼ in. wide made by placing a strip of corrugated paper in the joint and concreting against it. The paper was left in place. All other joints were plain, untreated butt joints.

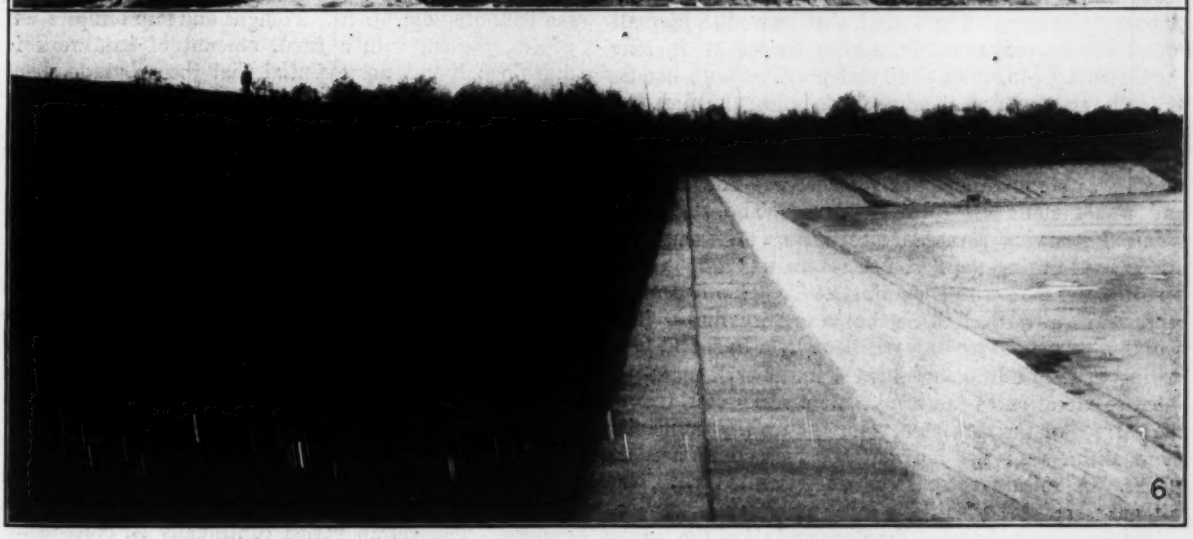
At the angles in the sides of the reservoir, a true cone-shaped transition was made (Fig. 1). A study of the formwork indicated that the best results would be obtained if joints were allowed along the slope as well as up and down it. Such joints had given trouble on a trial section early in the work on account of water entering as it flowed down the slope, scouring underneath the concrete and upheaving the lining at the foot by the hydrostatic pressure developed in spite of the weep-holes. To prevent this action a small strip of concrete was laid first in the subgrade at the horizontal joints. The device worked entirely satisfactorily. The raised joints were used on all joints running up and down the slope.

The entire bottom of the reservoir was level, the only provision for draining being at the gate chamber at the scrapers drawn by two horses and deposited either in the path of a near-by steam shovel or dumped in a spoil pile in case the shovel was at a distance. The finishing was done by men with mattocks or broad-edged picks trimming very closely to the prescribed lines. Hubs 2x2 in. were driven flush with the finished trimmed surface on lines 25 ft. apart each way, the hubs being later used for setting the forms for the concrete and for marking the joints. Boulders encountered in the bottom were allowed to remain if well below the finished surface of the concrete lining; otherwise they were blown out, all loosened material removed and the hole filled with concrete when the lining was placed.

The water impounded by rains often caused serious delays. After a short rain the mud was removed by scrapers or shovels ahead of the concreting gang without causing much interference. When much water fell, all operations were suspended. The water drained off slowly even when assisted by men with brooms and shovels to induce a current. Low earth dams were sometimes laid on the concrete lining already built to prevent that area from draining indiscriminately onto the graded portions. Various expedients were used, but usually progress was seriously impeded. In a few cases strips of lining 3 ft.



FIGS. 2 AND 3. PLACING THE CONCRETE LINING ON THE HILL VIEW RESERVOIR, NEW YORK CITY



FIGS. 4 TO 6. THE HILL VIEW RESERVOIR DURING AND AFTER LINING

Fig. 4—Looking over the reservoir while floor was being placed; dividing wall and conduit at right. Fig. 5—Screeding one of the floor panels. Fig. 6—Completed reservoir slope, showing concrete below, paved stone next above and riprap at top

wide were left open to assist in leading the water away, but their use was not general and in a very few cases ditches were allowed to be dug below subgrade for short distances. All such drainage channels were thoroughly cleaned to the natural material and concreted.

Placing Lining on Bottom of Reservoir

In the design of the lining on the bottom of the reservoir, expansion joints were specified to be formed not over 50 ft. apart in both directions. A spacing of exactly 50 ft. was adopted. The bottom was laid out in advance on that plan, and construction progressed in accordance with it. After experimenting with various methods, the contractor settled down on a policy of adjacent strips 25 ft. wide and as long as possible, 25 ft. being the practical limit for screeding width and screeding the most practical way for insuring a uniform thickness of concrete. A trial was made of the shovel-finish method used on the slope, but no feasible way was devised for keeping the thickness constant. Strips 12½ ft. wide were no easier to place than 25 ft., and alternate blocks 12½x12½ ft. and multiples of those dimensions entailed a considerable expense for setting and removing forms. The continuous 25-ft. strip proved to be well adapted and was used throughout practically the entire area (Fig. 4). Removable steel plates formed the expansion joints transverse to the direction of the strip, and corrugated paper laid against the concrete formed those in the longitudinal direction. The corrugated paper was left in place. The steel plate was well greased and a strip of building paper placed each side to facilitate withdrawal. The plate was kept in alignment by steel pins driven on each side. Timbers 4x6 in. were used for the forms along the outside edge of the strip of lining.

Concrete was handled into place in 1⅓-cu.yd. bottom-dumping buckets by a 15-ton Brownhoist steam-operated locomotive crane with a 52-ft. boom, running on track laid alongside, preferably, from the contractor's standpoint, on the concrete lining already built in order to give an unobstructed field for the trimming operations (Fig. 5). The concrete was sprinkled with a hose for about two weeks. The mix was 1:8 and of a rather sloppy consistency. The screed that gave the best all-round results was a 4x6-in. spruce timber 27 ft. long, shod with a ¼-in. steel plate and provided with handles at each end somewhat similar to plow handles. A camber of about ½ in. compensated for the sag, and it was found that the sag did not tend to increase. The screed was simply and quickly made, was not expensive and would stand all sorts of abuse. The steel strip required renewing perhaps twice during a season. The screed used during the first full season was a 2½x12-in. pine timber, shod with a $\frac{5}{16}$-in. steel T. This had ample stiffness in a vertical plane, but was very limber horizontally. As the screeding was done by a back-and-forth sawing motion, advancing about 4 in. at each move, the sidewise vibration of the screed left a series of ridges on the surface of the concrete. The 4x6-in. timber, having more stiffness in the horizontal plane, eliminated the ridges. A rolling screed was experimented with, but without success.

The concrete for most of the slope and all of the bottom was mixed in a 1½-cu.yd. Hains gravity mixer and transported to the work in bottom-dumping buckets on trailers hauled by third-rail electric motor cars running on 3-ft. gage track. The usual train consisted of one motor car carrying a bucket, and three trailers, two of which carried one bucket apiece. On the long hauls two trains were used and in a few instances three, turnouts being provided at suitable intervals. On the bottom the track for the motor trains was often laid inside the track for the locomotive crane, gage 4 ft. 8½ in., using one rail in common (Fig. 4). Two strips of lining, each 25 ft. wide, were usually placed by the crane from one position of the track. The maximum length of strip concreted was 2,300 ft. The area of the bottom was about 69 acres. The locomotive crane was used for moving both sets of track in all routine pregressive movements. The third-rail equipment was very elastic, gave excellent service, and only a few accidents, and those of no significance, occurred. The voltage was 550. The running rails were 40-lb. and the third rail 16-lb. The third rail was protected by a continuous covering made by two 8-in. boards at right angles to each other, supported by a light post and brace nailed to a tie about every 8 ft. (see Fig. 1).

Dry Rubble Paving and Riprap

From the berm, El. 280 to El. 287, the slope was faced with rubble paving laid dry, bedded in crushed stone. The paving stones were worked out of trap boulders, a plentiful supply being available from the excavation for the reservoir. The crushed stone was from the stock used for concrete. The slope of the embankment above the berm varied continually, no two adjacent sections being on the same slope. This was done to produce a sinuous shore line at all stages of the reservoir throughout the range of the daily fluctuations. The slope and cross-section of the paving and riprap were established in the office for every 25-ft. station around the reservoir (about 8,000 ft.) and sheets prepared for the use of the grade parties in the field. The non-uniformity of slope made it difficult to build up the embankment to the proper lines (embankment material was brought on in 4-yd. cars in 10-car trains), and in spite of stakes that were set for guidance at frequent intervals, considerable material required removal during the trimming operations. Ploughs and slip scrapers were generally used, with a small amount of handwork for finishing; it was not essential that the subgrade should be as accurately trimmed as for the concrete lining. The material was moved up the slope for removal. The stone was hauled in by wagons and dumped or rolled down the slope to the work. It was set to strings by men using bars. The slope of the top of the paving varied from 1 on 1.7 to 1 on 4.6, the thickness at El. 287 measured at right angles to the slope varying from 24 in. for the steepest slope to 18 in. for the flattest, the thickness at the berm wall being uniformly 18 in. About 250 ft. of slope was 1 on 2 or steeper, and about 150 ft. was 1 on 3.3 or flatter. For the remaining distance around the reservoir the slope lay between those two limits and about uniformly distributed.

Between El. 287 and El. 297 the slope was faced with riprap, El. 297 being 2 ft. above full reservoir level (Fig. 6). Above El. 297, the slope was finished with soil and grassed. The riprap varied continually in cross-section and slope, as did the rubble paving, but the finished surfaces were substantially in alignment at each 25-ft. station. Where the riprap joined the paving, the thick-

ness was identical for the flattest slope and 6 in. less on the steepest. At El. 297, the thickness was uniformly 2 ft. and vertical. The intermediate thickness, measured vertically, varied from 5.7 ft. for the steepest slope to 3.3 ft. for the flattest. The trimming methods were similar to those used for the slope paving. The riprap was dumped, cast or rolled into place, depending on the size of the stones and the condition of the slope. Sound and durable boulders of all sizes from the reservoir excavation were used. No handwork was required or used except in the final lining up of the surface.

Expansion Cracks and Frost Action in Lining

The provision for expansion and contraction in the concrete lining proved to be entirely satisfactory. One block on the bottom laid as a monolith 50 ft. square developed only one crack, and that diagonally across a corner, indicating frost action rather than contraction. The effect of frost was quite noticeable in the case of the small experimental sections on the bottom and was probably more or less general over the entire area, the concrete settling down again in the spring. Heaving was general on the berm and practically general on the slope, a crack usually showing on the slope not far below the berm. Only one crack, however, developed in the length of the strip. This lining did not tend to settle back into place, probably from the fact that surface water penetrating below it carried sediment or transported some of the underlying material. The weep-holes usually performed their function, but hydrostatic pressure was produced in two or three localities. In some cases water issuing from the weep-holes carried earth with it, but no settlement of the slabs was noticed. No trouble was experienced at the corners. No movement of any kind was ever detected in the berm wall or toe wall. None of the lining was seriously displaced in spite of the fact that some was exposed for two winters. Wherever possible, the concrete was protected during construction by flooding during the winter. After the reservoir has been put into service, the lining will be submerged, and no further disturbance is to be expected.

Behavior of Slope Paving and Riprap

The reservoir was filled for the first time in December, 1915, and has not been drawn down since, so that a complete inspection of the slope paving and riprap has not been possible. At a few disconnected places, the soil has worked into the upper edge of the riprap, and over a stretch of several hundred feet a general erosion of soil by waves took place during a very heavy northwest gale. The wave action was effective for about 5 ft. above the water level at the points of steepest riprap slope, about 1 on 2. As the slope flattened, the erosion diminished, the waves expending their force before reaching the soil. Some settlement of the riprap is visible at intervals, but it is not general in extent or serious in amount. On account of the short time that this portion of the slope protection has been subjected to service conditions, no general conclusions can be drawn. The reservoir is regarded as highly satisfactory.

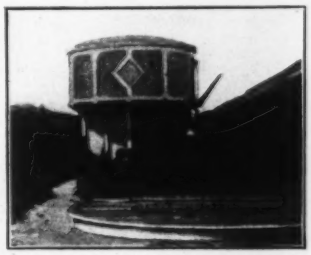
J. Waldo Smith is Chief Engineer of the Board of Water Supply, with Department Engineer Frank E. Winsor and Division Engineer Charles E. Wells in charge in the field during construction. The contractor was the Keystone State Construction Co., of Philadelphia.

Concrete Railway Water Tanks Eleven Years Old

The ornamental reinforced-concrete tank shown in the accompanying view is one of two tanks which were built in 1905 and are thought to be the first tanks of this type adopted for railway water stations. They are still in use and have proved entirely satisfactory. Each is of 60,000 gal. capacity and has the floor about 14 ft. above the rails.

These tanks are at Notasulga, Ala., on the Western Railway of Alabama, and at Hogansville, Ga., on the Atlanta & West Point R.R. Their cost was lower than that for steel tanks of the same capacity. They were designed and built by the Southern Ferro-Concrete Co., of Atlanta, Ga. Information has been given by O. T. Nelson, Superintendent of Maintenance-of-Way of the railways mentioned.

The tank is circular, 29 ft. 8 in. in outside diameter and 12 ft. 6 in. high. It is carried by girders on a circular row of outside columns 12x12 in. and a single central column 14x14 in. The wall is 4 in. thick, reinforced with rings of $\frac{3}{8}$- to $\frac{9}{16}$-in. rods spaced 5 to 8 in. c. to c. and with vertical $\frac{5}{16}$-in. rods. These latter are spaced 12 in. c. to c. and hooked over the top and bottom rings. The 4-in. floor is reinforced in both directions. Between the columns it has $\frac{5}{16}$-in. rods 12 in. c. to c.; outside of the columns it has $\frac{3}{8}$-in. rods 6 in. c. to c., alternate rods being bent up 18 in. into the side wall. The dome roof is 30 ft. 4 in. in diameter, with a rise of $2\frac{1}{2}$ ft., and has a 36-in. manhole at the center. This concrete is 2 in. thick reinforced with $\frac{3}{16}$- and $\frac{5}{16}$-in. rings, 12 in. apart, and with $\frac{1}{4}$- and $\frac{5}{16}$-in. radial rods. The latter have their ends hooked to a $1\frac{1}{2}$-in. rod in the coping.



RAILWAY WATER TANK OF REINFORCED CONCRETE
(Built in 1905)

The concrete was made with pit-run gravel from the railway company's pit at Chehaw, Ala. It was thoroughly mixed, of fairly wet consistency and laid as nearly continuously as possible. The mix was 1:2:4 for the tank and 1:2:5 for the other parts. As soon as the forms were removed, the floor and wall were given three $\frac{1}{4}$-in. coats of 1:1 cement mortar. After the tanks were filled, moisture appeared on the surface, but not to such an extent as to drip. This disappeared after a few weeks, and the tanks have since held their full amount of water.

A 4-in. curtain wall is built between the columns to form a storage room or toolhouse. The paneling of the tank adds to the pleasing effect of the design, and the diamond-shaped panel on the face (lettered "The West Point Route") is the railway company's trade-mark.

A Monorail Carrier for Lumber, with a length of about 25,000 ft., is to be installed at the lumber mill and yards of the Letcher & Moore Lumber Co., Galveston, Tex. The line will have 30 switches and about 45 curves of 30-ft. radius. It will be operated by three carriers or trolley hoists, traveling at 600 ft. per min. when light or 500 ft. per min. with load. Each carrier will have a 20-hp. motor for the hoist and a 15-hp. motor for traveling. They will handle 5-ton loads of lumber, in lengths up to 24 ft. This monorail system will be built by Pawling & Harnischfeger, Milwaukee, Wis.

Traveling Sewage-Distributor Changes, Springfield, Mo.

By Alexander Potter*

Concerning the design and construction of sewage-disposal plants, especially the novel features incorporated therein, much has been written in the past, but comparatively little is published concerning their operation under working conditions. Two years experience at Springfield, Mo., with power-driven sewage distributors installed principally because of the low head available—12 in.—is, therefore, of value. (For description of the Springfield sewage works see *Engineering News*, Dec. 4, 1913.)

The sewage distributors referred to in this article were manufactured at Birmingham, England, by Ham-Baker & Co., Ltd., and placed in operation in the fall of 1913. The type used is illustrated in Fig. 1, except that the motor and gear shown upon the carriage (which will be referred to later on) replace the original "gear" for releasing the right-hand clutch from the cable at the end of the run and engaging the left-hand clutch on the return drive. Distribution is accomplished by means of two steel feed tubes, each 7 in. in diameter, supported at each end and at the center by a cast-iron carriage braced together by rolled steel beams so as to form a rigid structure. Located in each feed tube in a line just above the horizontal diameter are 5/8x4-in. orifices, 15 in. c. to c. Lateral distribution can be further controlled by a distributing tube, 2½ in. in diameter, located just below the center of the two feed tubes. This distributing tube is built in 6-ft. lengths and can be raised and lowered to secure uniform transverse distribution onto the bed.

When the distributors were tested it was found that the 5/8x4-in. orifices were entirely too large for their purpose. Instead of acting as orifices, as intended, they acted under normal operating conditions as weirs, those located nearest to the siphon discharging so much of the sewage that the tube regulators could not be adjusted to give a satisfactory transverse distribution. Before the plant was placed in operation, this defect was remedied and a uniform distribution was secured by providing the orifices with adjustable slides and by shortening the length of those orifices which were discharging the sewage at too high a rate. Fig. 2 shows the siphon end of one of the distributors, the distributing trough, and, in the background, a distributor in operation. This distributor is operating under a head of 9 in., measured from the water level in the distributing trough to the top of the finished grade of the filter bed.

In designing and constructing the plant, the writer made provision so that in case it should be found impracticable to operate the distributors during zero weather their use could be temporarily discontinued and the filters used as contact beds. Although the winters at Springfield are severe, it has never been found necessary, because of freezing weather, even temporarily to abandon the use of mechanical distribution. With temperatures below 0° F., ice has never collected in the distributing troughs of the filters or in the distributors themselves in sufficient quantities to interfere with the operation of the distributors, neither has there been any interference with the operation of the distributors from ice collecting on the filter beds. However, during times of freezing rains it was found that the ice collecting on the driving cables tended to clog the reversing clutches and stall the machinery, requiring the constant attention of the operator to keep the plant running.

FIG. 1. TRAVELING SEWAGE DISTRIBUTOR FOR SPRINKLING FILTERS, SPRINGFIELD, MO.

Although the experience at Springfield shows that mechanical sewage distributors can be operated successfully in all kinds of weather by means of the cable drive generally used with this type of machine, the writer does not recommend at this time the use of cables because of their high cost of maintenance and operation. At Springfield it was found that the cables had to be replaced every six months, deterioration being due to wear and tear accentuated by corrosion, the cables being more or less exposed to the spray. In addition to the rapid deterioration of the cables, the guide pulleys, rollers, etc., were found to wear out rapidly, and needed frequent replacing.

The experience at Springfield with cable-driven Ham-Baker traveling sprinklers is similar to that at Glasgow, Scotland, where in June, 1913, four distributors of the same type were installed at the Dalmarnock Works. It is reported that the rope drive for these distributors was found to be unsatisfactory, the cables, ball bearings, sheaves and pulleys wearing out rapidly and giving no end of trouble.

The average yearly cost of operating the six traveling distributors at Springfield was about $350 per year for

*Consulting Engineer, 50 Church St., New York City.

the maintenance and renewal of cables, pulleys, rollers, chains and clutches, and $480 for gasoline and cylinder oil, the six machines being driven by a 6-hp. Otto gasoline engine.

In so far as the city was concerned, the attitude of the administration seems to have been that the city had fulfilled all the obligations required by law when it had constructed the sewage disposal plant and that there was no serious obligation resting upon the city for the proper and effective maintenance of the plant. As a result, some of the distributors could not be operated at times, due to lack of spare cables or other essential parts. Fortunately, the city had placed in charge of the plant J. E. Guinn, a resourceful man of considerable mechanical ability. When in the fall of 1914 one of the distributors was out of order, due to a worn-out cable, no spare cable being at hand, he substituted, largely at his own expense, for the cable drive a direct motor drive for this distributor, as shown in Fig. 3.

The device is a very simple one. A ¼-hp. motor, mounted directly upon the frame of the distributor, operates the driving mechanism by means of a belt. The speed is reduced by a set of worm and bevel gearing to about 38 ft. per minute. Reversal of direction is secured by stops, securely fastened, one at each end of the track. This stop trips the lever handle *A*, Fig. 3, attached to a sliding collar *B*, which engages by means of a lug the proper bevel gear *C*.

At the end of its run the distributor is brought to rest by means of a spring buffer. The mechanism on being reversed by the stop can make a complete turn of the driving bevel gear before the gearing is positively engaged. This short period of rest is sufficient to permit the energy stored up in the compressed spring of the buffer to start the distributor on the return travel without undue shock to the driving mechanism.

After having thoroughly tried out the direct motor drive on one of the distributors and having found it to be a decided improvement over the cable drive, the writer recommended its installation on all of the six units, which has since been done.

The advantages of the direct drive as compared with the cable drive are:

1. Saving in power, the brake horsepower required to operate the six units being reduced from 3 to 1, as determined by actual test.

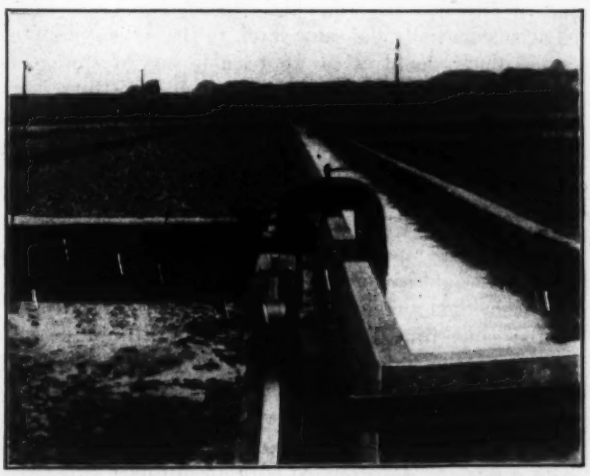


FIG. 2. SIPHON AND SEWAGE-DISTRIBUTING TROUGH

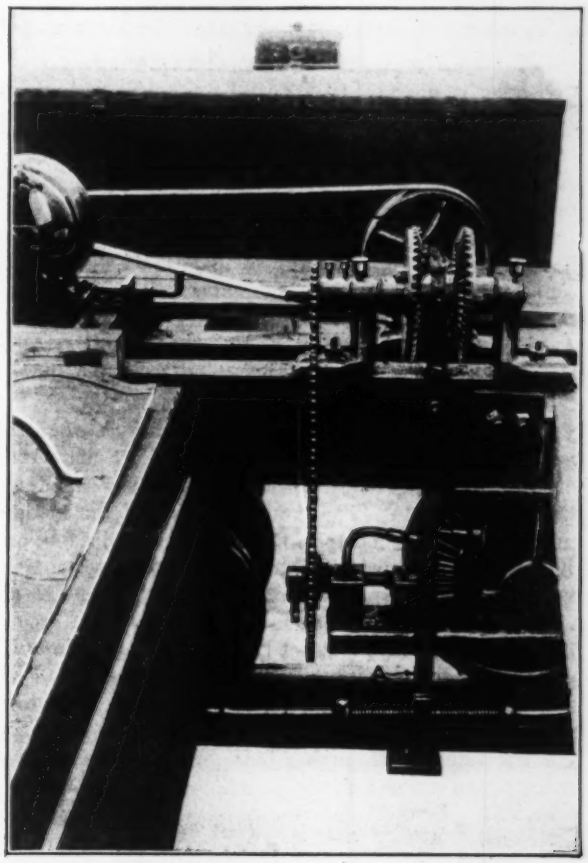


FIG. 3. DIRECT MOTOR DRIVE FOR SEWAGE DISTRIBUTOR

2. Saving in first cost. The cost of installing the direct drive is less than one-third of the cable drive.

3. Saving in moving weight. The motor-driven unit weighs 700 lb. less than the cable-driven unit.

4. Length of filter unit can be increased at will, thus reducing the number of travelers per unit of area. With the cable drive the economic length of a filter unit is limited to 200 ft. For lengths greater than this the cable becomes so heavy as to make it difficult to operate.

5. Saving in maintenance. The maintenance cost of the direct drive averages about one-sixth of the cable drive.

The accompanying table is a comparison of the cost of operating the mechanical sewage distributors at Springfield by the two methods. The figures given are exclusive of the cost of installation and fixed charges on the distributors proper, rails, etc., items common to both drives. Including all these items, amounting to $7,000, the total cost of distribution per million gallons becomes $1.25 for cable drive and $0.61 for direct motor drive.

COMPARATIVE COST OF CABLE-DRIVEN AND MOTOR-DRIVEN SEWAGE DISTRIBUTORS, SPRINGFIELD, MO.
Six units, each 53x200 ft.; speed of distributor, 36 ft. per min.

	Cable Drive	Direct Motor Drive
Prime mover	Two 6-hp. Otto gasoline engines	Six ¼-hp. motors
Average b.hp. developed	3	1
Cost of installation	$3,000	$900
Yearly cost of power	480	200
Yearly cost of maintenance	350	50
Total of fixed charges, maintenance and operation	1,010	304
Cost of distribution:		
Per acre per year	692	208
Per million gallons	0.92	0.28

Water Equalization Between Distant Standpipes

By Charles W. Sherman*

It sometimes happens that it is desirable to have two or more standpipes a considerable distance apart, to furnish storage in a water-works system. In such a case the loss of head while pumping is going on will seldom be the same to both standpipes, and if both are freely connected with the mains the water will not stand at the same elevation in both while they are being filled. As soon as pumping ceases, however, water will equalize between the two standpipes, and a portion of the storage capacity theoretically available will be lost.

Under certain conditions the capacity which would be lost in this way may be very considerable. Such a condition existed at Needham, Mass., where a new standpipe was built in 1915. The circumstances and the method proposed to overcome the difficulty are described below.

Fig. 1 shows in outline the main piping system between the pumping station and the standpipe in Needham, leaving out of consideration all pipes 6 in. or less in diameter and all pipes not lying between the pumping station and the standpipes. The works were built some 25 years ago, the water being pumped from wells to a standpipe on Ryan's Hill. This standpipe is 25 ft. in diameter and 85 ft. high. Last year, for the purpose

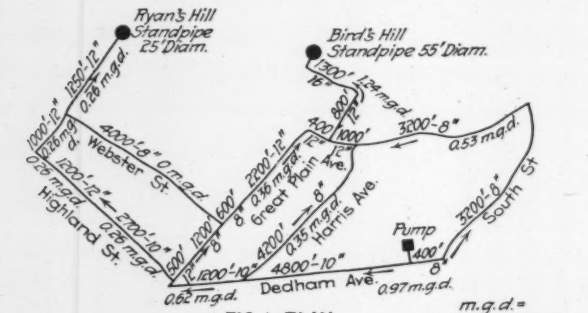


FIG. 1, PLAN

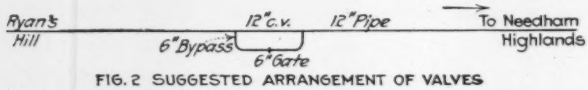


FIG. 2 SUGGESTED ARRANGEMENT OF VALVES

WATER EQUALIZATION BETWEEN STANDPIPES

of furnishing additional storage and better to protect a rapidly growing portion of the town, a tank 55 ft. in diameter and 44 ft. high was built on Bird's Hill. The main pump at the pumping station has a capacity of 1,500,000 gal. per day.

With a complex network of pipes and with water abstracted from the pipes for consumption at various points all along their extent, it is obviously impossible to make precise computations. For the purposes of approximation all of the mains were assumed to be in substantially identical condition as regards age or roughness of interior surfaces, and the coefficient $c = 100$ in the Hazen and Williams formula was assumed. Computations were made by the Hazen and Williams slide-rule.

Assuming a condition when no water is being consumed from the pipes and all of the water pumped goes into storage in the standpipes, it is obvious that within a very few minutes after starting the pumps a condition of equilibrium will be attained, with a certain proportion of the water going to each of the standpipes and with a definite loss of head between the pumps and each tank. The loss of head from the pump to each tank will remain constant, and the hydraulic grade lines will simply rise parallel to themselves as the tanks fill; that is to say, the water level will rise at the same rate at both of the tanks. Under the existing circumstances, therefore, the standpipe on Bird's Hill being so much larger in diameter than that on Ryan's Hill, nearly five-sixths of the water pumped goes to Bird's Hill standpipe, or, with the pump running at a rate of 1,500,000 gal. per day, water will be going to Bird's Hill standpipe at the rate of 1,240,000 gal. per day and to Ryan's Hill at the rate of 260,000 gal. per day.

It had originally been assumed locally that, because the Bird's Hill standpipe is so much nearer the pumping station, the loss of head would be less and the Bird's Hill standpipe would be full before that on Ryan's Hill reached the overflow. A consideration of the relative quantities flowing to the two standpipes and the almost insignificant loss of head between the corner of Dedham Ave. and Great Plain Ave., and the Ryan's Hill standpipe showed on the contrary that there would be a considerably larger loss of head from the pumps to Bird's Hill than to Ryan's Hill. A series of approximate calculations indicated that the total loss of head from the pumps to Bird's Hill would be about 34 ft. and to Ryan's Hill about 27 ft., or that the standpipe on Ryan's Hill would overflow while that on Bird's Hill still lacked about 7 ft. of being full. Under such conditions, of course, pumping would be stopped and water would equalize between the two standpipes, with a drop of nearly 6 ft. at Ryan's Hill and a rise of but a little over 1 ft. in the Bird's Hill standpipe. The upper 6 ft. of the Bird's Hill standpipe would, under such circumstances, be substantially useless.

It is obvious that in order to have both standpipes fill simultaneously the total loss of head from the pumps to both of the standpipes must be the same. This result can be obtained by inserting resistance in the pipe line between the pumps and the Ryan's Hill standpipe, as for instance by partly closing a gate near the base of the standpipe. This could be done experimentally in such a way that the water level in the two tanks would be at substantially the same level, so that when pumping ceased there would be no appreciable loss of storage in either tank due to equalization. Such throttling, however, would render the water stored in the Ryan's Hill standpipe practically useless for fire purposes, since the loss of pressure in getting water out of the standpipe at high velocities, through a partly closed valve, would be considerable, and in case of a fire in that section of the town while the pumps were not running, the pressure available would be very largely reduced.

The method suggested to overcome this difficulty and at the same time to make possible throttling the gate leading to the standpipe so as to equalize the elevations during pumping is shown in Fig. 2. A 12-in. check valve opening outward is to be inserted in the pipe leading from the standpipe a short distance from its base, with a 6-in. bypass supplied with an ordinary gate valve. The 6-in. connection of itself would serve to reduce the

*Of Metcalf & Eddy, Consulting Engineers, Boston and Chicago.

pressure somewhat, and by throttling the gate experimentally the proper degree of equalization can be obtained, while the 12-in. check valve opening outward would make available the full capacity of the standpipe at once in case of sudden fire draft.

Creating a Popular Demand for Water Meters

What may be accomplished in creating public sentiment in favor of adopting water meters and in promoting the business of a private water company is shown in the experience of the San Antonio (Tex.) Water-Supply Co., of which Robert J. Harding is vice-president and general manager.

The water-supply of the city comes from artesian wells at the main pumping station, which is in the heart of the city, and from artesian wells at a suburban pumping station. The water-bearing strata extend under practically the whole city, so that any private party may have a well boring 800 or 1,000 ft. In order to obtain the business of all the water consumers, the water-works plant must not only be economically operated, but the water company must have and keep a certain amount of popularity.

The rates for water service of various characters are fixed by a 10-yr. contract, made in 1914, between the

Water Rates
Flat rates may be very unfair to the consumer of water.
Flat rates may be very unfair to the Water Company.
Water sold by meter is never unfair to the consumer.
There is a way to reduce your water bill.
Water meters do not over-register.
San Antonio Water Supply Company
Worthy of Attention
Our meter rate for water for domestic use is at the rate of 23 barrels for 11 cents. Compare this rate with that which you paid in your old home town.
San Antonio Water Supply Company
Ask Your Neighbor
IN OUR various advertisements we have conclusively shown that water meters do not over-register, that the meter rate is unusually low, and that you will be better pleased to purchase water by meter.
Now ask your neighbor, compare notes, and when you have concluded, notify us and we will include you with the rest of our 6,000 satisfied metered consumers.
San Antonio Water Supply Company

FIGS. 1 TO 3. NEWSPAPER ADVERTISEMENTS WHICH CREATED A POPULAR DEMAND FOR METERS

city and the water company. The city in a large measure prescribes the rules and regulations governing the service of the company. The price fixed for a service connection is $15 for a ½-in. pipe and $20 for a ¾-in. pipe. The company installs lead service pipes inclosed in 4-in. tile, so that it loses money with practically every installation.

The contract with the city makes the installation of water meters optional with the consumer, or in the case of improper use or waste of water the company may insist on the installation of a meter. Notwithstanding the fact that the company buys and installs the meters, the old popular prejudice against the metering of anything as plentiful as water prevailed until Mr. Harding decided to convince the people of the real economy of water meters. To this end he inserted newspaper advertisements, of which Figs. 1, 2 and 3 are samples. By this means a popular demand for meter installations was created—a greater demand than the meter-purchasing budget of the company could meet.

Another use of advertising has been to promote the consumption of water. The pumping plants are of course most economically operated when they are running to capacity. Hence, to increase its revenues, the company has encouraged the legitimate consumption of water. This is purely a business consideration; but, as will readily be seen, it is founded on the principles of economical operation, which would apply with equal force to municipally owned water-works. The tendency too often is

GROWING
NOW is the time to arrange with Nature to do something for you. Rosen we now will furnish cut flowers for the Spring Carnival. Fruit trees, shade trees, ornamental shrubs and evergreens should be planted. In fact, if you want to start something, just sprinkle water here with a liberal supply of water and watch the green grass appear.
If you are having water on a flat rate, get your money's worth. If you are on a meter, it's the cheapest thing you buy.
San Antonio Water Supply Company
Throw Away the Can Opener
You have the soil, the climate and the water, and with a very little energy your table can be supplied with fresh vegetables. A garden from which during every month of the year you may reap a reward for your efforts.
Don't let water at ten barrels for a nickel, delivered, stand in the way.
San Antonio Water Supply Co.
New Service Pipes
When you need a lead service pipe in preparation for a new pavement or to renew your old galvanized one, remember this.
We recommend for an ordinary eight-room residence a half-inch pipe from the water main to the property line if you are on the near side of the water main. If on the far side, it should be a three-quarter.
Simply the disrupting of the pipe in the street will not correct the trouble in the paving on your property. Regardless of the size of the lead service, make the pipe in your yard one inch.
San Antonio Water Supply Co.

FIGS. 4 TO 6. ADVERTISEMENTS TO PROMOTE WATER USE AND INDUCE NEW CONNECTIONS

to discourage consumption on general principles without consideration of the most economical capacity of the plant.

The normal climate of San Antonio is fairly dry, and to keep grass and flowers requires a little irrigation. To encourage the use of water for this purpose, advertisements like Figs. 4 and 5 have been found effective. Another use of the newspaper advertising columns has been to encourage the installation of new services before street-paving operations were begun (see Fig. 6). The profit in this was more the good will of the city authorities than increased consumption.

The result of this publicity work, together with a fair and open policy of administration of the water company, has had quite a remarkable effect on public sentiment generally. It has also had a rather odd psychological effect in convincing employees. Although well primed with arguments in favor of water meters, the employees are apparently themselves convinced by reading the advertisements and are ever afterward most earnest advocates of the company's policy.

Sewer Pipes from Hawaiian Molten Lava—The making of sewer pipes and bricks of the molten lava from the active volcano Kilauea is advanced as a business proposition by W. S. Townsend, a retired Ohio manufacturer of sewer pipes, who visited the Hawaiian Islands in February. The volcano is on the Island of Hawaii, 32 mi. from Hilo, and reached directly by automobile over a smooth road that dips down through a break in the wall of the old crater to the floor of dead lava and thence almost to the brink of the pit of Halemaumau (House of Everlasting Fire). Mr. Townsend declared that, with proper machinery, pipes could be molded from the lava in exactly the same manner as pipes are molded from molten material in foundries. He advanced a plan to erect endless bucket conveyors that would bear the lava out of the pit, the buckets to be made of a special material capable of withstanding heat up to 2,000° F. (The research work now being carried on under the direction of Prof. T. A. Jagger, of the Massachusetts Institute of Technology, has proved that the temperature of the molten lake is about 1,800° F.) Mr. Townsend expressed the belief that the lava would remain liquid during the short time it would be on the way to the molds, which could be placed in a building near the edge of the crater. For the past 10 yr. the Lava Brick Co., Honolulu, has been making building bricks from lava rocks. Its plant is located in the district of Kaimuki, where there is a vast outcropping of lava rocks from ancient volcanic flows. These bricks are gray in color and have been used extensively in the construction of buildings and particularly in sewer, manhole and fireplace work. Mr. Townsend's idea was considered quite unique in Honolulu when made public and has been taken seriously.—"Commerce Reports."

Spring Water for Fort Huachuca

By R. C. Hardman*

The growth and importance of a community in the arid Southwest are often contingent upon the extent of its water-supply; consequently, the smallest source of potable water is not neglected. Fort Huachuca, Ariz., a cavalry post near the Mexican border, was limited in this respect, the old water-supply derived from springs in the cañon above the post being barely adequate for the six troops of cavalry quartered there. During the border troubles of the past five years large increases have been made in the garrison, often more than double its normal allotment. The old water-supply, while sufficient during the winter and the rainy season in July and August, was so small at other times that the use of water had to be prohibited for several hours during the day, to allow water to accumulate in the reservoirs. To remedy this condition and to provide for any desired permanent increase in the garrison, three small springs furnishing the supply for what might be called an intermittent stream in Garden Cañon, about 9 mi. distant, were developed and the water carried to Fort Huachuca (see Fig. 1).

The flows from the springs were measured by means of rectangular weirs for a period of several months, the period commencing in early spring before the winter snows had disappeared and continuing through the extremely dry early summer and the July and August rains. The discharges were computed by the Francis formula, the combined results obtained being shown in the accompanying diagram.

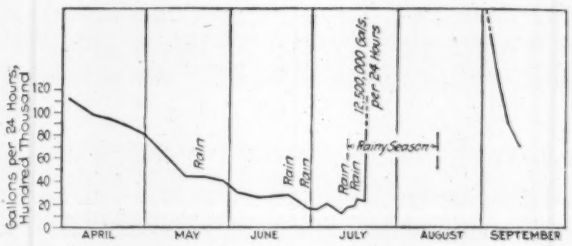


FIG. 2. FLOW OF SPRINGS, FORT HUACHUCA WATER-SUPPLY

The springs were located in a limestone formation said to be very similar in appearance to the Mammoth Cave region. About a quarter of a mile above weirs 1 and 2 was a cave, unnoticeable in the dry season, which in the wet season poured forth a stream of water some 20 ft. wide and from 6 to 8 in. in depth, apparently from a subterranean lake. As will be seen from the diagram (Fig. 2), the entire flow of the stream at weirs 1 and 2 (weir 2 measured the flow from weir 3, together with about a mile of stream between 2 and 3) fell to 120,000 gal. per 24 hr. during the dry season. This flow (0.1856 sec.-ft.) was taken as the minimum. During this period of low flow, of the nine creek crossings made by the pipe line five were absolutely dry, the flow being carried by subterranean channels. The maximum flow observed was, as nearly as it could be gaged, about 12,500,000 gal. per 24 hr., or 19.33 sec.-ft. The method of collecting the flow from the springs and the creek above them is seen in Fig. 1.

The main springs burst forth from the side of a 45° slope and were surrounded by numerous seepages. A small concrete collecting gallery was provided to receive the entire flow by intercepting the normal flow to the creek. As will be seen, the collector was provided with an 8x12-in. opening on its upper side, in front of which were placed broken stones to prevent the entrance of foreign matter likely to obstruct the pipe. The natural formation of the site made it easy to collect the water from the creek itself. Immediately below weir 2 is a limestone ledge about 6 ft. in height, at the foot of which is a natural pool some 5 ft. in depth that receives the entire flow of the stream in times of normal flow. A 6-in. pipe connects this pool with the collector. In times of flood

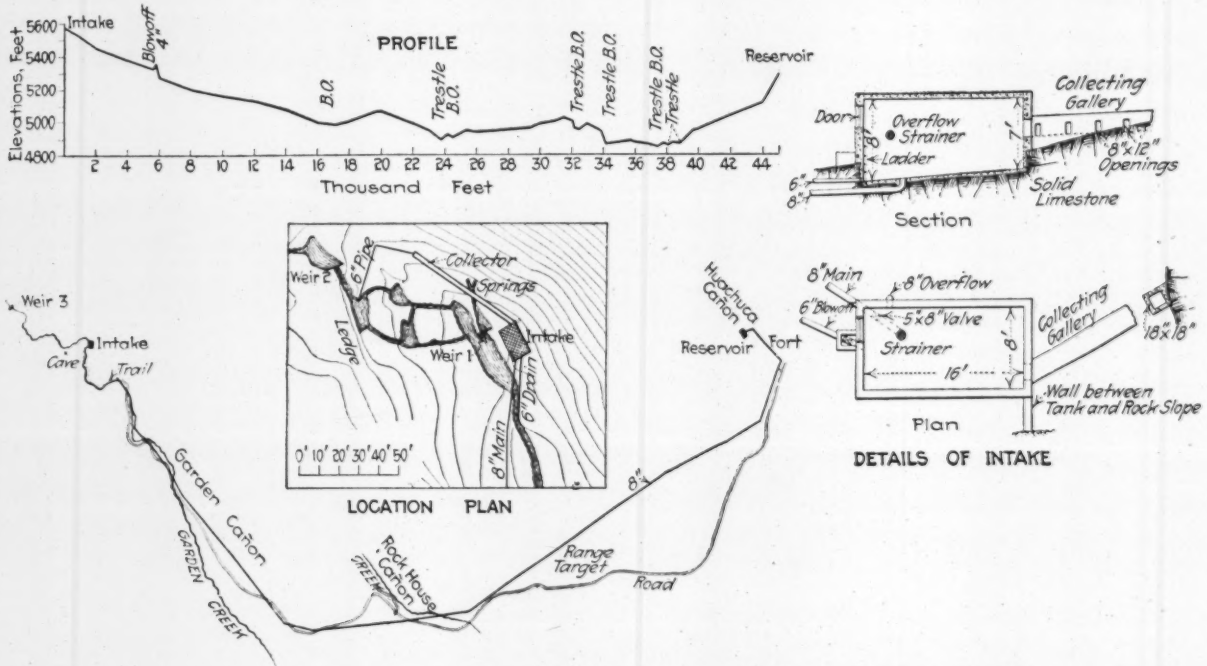


FIG. 1. DETAILS OF THE SPRING WATER-SUPPLY OF FORT HUACHUCA, ARIZ.

*Colorado Springs, Colo.

the stream cascades from the ledge to a point considerably below the intake chamber.

The intake presents no unusual features. The construction of the pipe line, which is of 8-in. steel pipe with Dayton couplings, was relatively easy. About 1½ mi. was through loose and solid rock, the remainder through a hard adobe soil thickly interspersed with granite boulders. The ground was so heavily strewn with boulders over most of the line that hauling was difficult. All material for the construction of the intake works and the last half mile of line had to be transported on burros, because of the extremely rugged nature of the cañon.

The line was carried over several arroyos on timber trestles; elsewhere 18 in. of cover was provided. At the reservoir end the pipe discharged into a reinforced-concrete tank 4 ft. in diameter, placed upon the dividing wall between the two concrete reservoirs. The water was delivered to either reservoir, as desired, by means of gates in the sides of the tank. No valves were placed at the reservoir end, so that the line cannot be subjected to a static head, which would place the low point of the line under a pressure of 312 lb.

Horizontal angles were made by long curves wherever possible, but in the upper part of the line the cañon was so restricted that cast-iron specials were used. The total curvature of the line is 1,070°, of which 763° is in the first 5,569 ft.

The labor on the work was entirely Mexican, at $1.75 per 8-hr. day. A gang of five men laid and jointed up as much as 3,000 ft. of pipe in one day, although this was far above the average and only possible on long tangents. Along the upper end 300 ft. per day was considered good.

The line was subjected to a test pressure of 250 lb. during construction, with the development of but one leak in the Dayton couplings, which was due to the absence of one bolt.

The work was designed by P. E. Borchers and built by Griffith & Pacheco, Tucson, Ariz., with R. C. Sparks as superintendent for the contractors and the writer as superintendent of construction for the War Department. The cost of the work was approximately $40,000.

Brick and Asphalt Paving by Day Labor

By G. C. Brehm*

In the past year 1,374 sq.yd. of brick and 16,728 sq.yd. of asphaltic-macadam paving have been constructed by day labor in Waynesboro, Penn., under the writer's supervision. In the case of the brick pavement the grading was very heavy and extremely hard on account of resurfacing the roadway with macadam for several years previous to the construction of the brick pavement. The average cut was 16 in. of solid macadam.

The base was 4 in. thick and consisted of a mixture of 1:2 ½:5 (limestone) mixed with a Colton continuous mixer. The sand cushion was 2 in. deep. Most of the sand was procured from the foundry of a local factory, the only cost being for the hauling. This bed was prepared with great care. After being drawn off with a templet it was rolled with a 500-lb. roller; all the depressions were then filled, the templet drawn over it and again it was rolled. This operation was repeated at least three times. When the brick had been placed and thoroughly rolled with a 6-ton roller, the surface was sprinkled and a 1:1 cement grout applied in the usual manner. Expansion joints 2 in. wide were placed along the curbs on both sides of the street.

Of the 16,094 sq.yd. of asphaltic-macadam pavement, 6,122 yd. was laid on Clayton Ave. on a crushed-stone base 2½ in. thick, after rolling. No grading was necessary on this street, but the fine stone used contained about 75% dust and had to be screened. Haulage was high, because the stone was loaded into wagons by hand shoveling. The binder was Aztec asphalt, which was applied by means of pouring cans.

The cost of this work was 41c. per sq.yd., divided as shown in the table.

COST DATA ON 6,122 SQ.YD. OF ASPHALTIC MACADAM PLACED BY DAY LABOR

Unit	Amount	Rate	Total Cost	Cents per Sq.Yd.	Total Cents per Sq.Yd.
3-in. and 2-in. stone	696.2 tons	$0.90	$643.30	10.51	
	20.9 tons	.80			
Hauling, 1 mi.	505	.50	252.50	4.12	
Spreading	295	.16	47.20	.77	
Rolling	74	.25	18.50	.30	
Coal	2,500 lb.	.002	5.00	.08	
Oil	1½ gal.	.50	.75	.01	
Supervision			15.00	.25	16.03
Asphalt	13,507 gal.	.061	823.93	13.46	
Hauling	53	.50	35.78	.58	
	58	.16			
	108	.20			
Applying	342	.18	167.80	2.74	
	529	.16			
Wood	6 cords	6.00	36.00	.59	
Oil and waste	27½ gal.	.12	5.55	.09	
	15 lb.	.15			
Supervision			60.00	.90	18.36
1-in. and ¾-in. stone	99.2 tons	.90	89.28	1.46	
Hauling	83	.50	41.50	.68	
Spreading	1.39	.16	22.24	.36	
Rolling	20	.25	5.00	.08	
Coal	1,500 lb.	.002	3.00	.05	
Oil	3 qt.	.125	.37	.006	
Supervision			8.00	.13	2.76
¾-in. stone	49 tons	.90	44.10	.72	
Hauling	51	.50	25.50	.42	
Spreading	123	.16	19.68	.32	
Rolling	15	.25	3.75	.06	
Coal, oil and supervision			91.35	.15	1.67
Miscellaneous (clean-up)			121.00	1.98	1.98
Total			$2,540.08		40.80

Another street, Church St. (North to Third St.), was paved with the same sort of material. Here, however, a small amount of grading was necessary. The total yardage was 4,243 and the cost was $1,745.79, divided as follows:

Grading	$120.65	$0.028
Bed stone (labor)	35.46	.008
2-in. stone (labor)	152.08	.035
¾-in. stone (labor)	32.35	.007
½-in. chips (labor)	45.04	.010
Hauling asphalt	44.74	.010
Pouring asphalt	91.12	.021
Miscellaneous	44.66	.010
Coal, wood, oil, etc.	44.89	.010
Stone	625.50	.147
Asphalt	509.30	.120
Total	$1,745.79	$0.406

On Cleveland Ave. 4 in. of crushed stone was placed on the rolled subgrade, covered with screenings and then thoroughly wet and rolled. A stone base 2 in. thick was then spread over this and the asphalt was applied. Just enough ¾-in. stone to take up the voids was then spread over the hot asphalt and the whole was again thoroughly rolled. After applying about ½ gal. of asphalt per sq.yd. the surface was covered with ½-in. chips and rolled. Bermudez asphalt was used on this street. The total cost of the work here was $515.05 for 634 sq.yd., or 80c. per yd.

On two other streets 5,729 sq.yd. was constructed at a cost of about 43c. per sq.yd. The old macadam street was used for the base, and on this 3 in. of stone was placed and then the asphalt, which was Aztec.

*Borough Engineer and Commissioner of Public Works, Waynesboro, Penn.

Rogers Pass Soft-Ground Work

By J. G. Sullivan*

Tunneling by such a method as to make the larger part of the excavation yardage accessible for steam-shovel mucking is the feature of the Rogers Pass tunnel work on the Canadian Pacific. This method might not seem well adapted to soft-ground work, but it has been applied with full success in the two portal sections as well as in several soft-rock sections farther in.

At the east end there was 1,300 ft. of tunnel through more or less cemented mountain débris. The method followed here was first to drive two wall-plate drifts (see Fig. 1 herewith), then stope out between these two drifts at various points (Fig. 2) and place five-segment arch timbering (Fig. 3). The core of the cross-section and everything below the wall plate was excavated by steam shovel (Fig. 4), the shovel removing over 66% of the total excavation in this section.

Practically the same method was followed in several soft spots encountered in solid rock. The tunnel was stoped out to the level of the wall plate and the arch timbers placed.

Seven-Segment Method in Loose Wet Ground at West End

At the west end there was about 400 ft. of very heavy ground, consisting of much looser material than at the east end. It contained large boulders and carried considerable water. The method employed here differed from that used at the east end in some important particulars. A seven-segment arch was used, and it was carried directly on posts instead of on a wall plate. To set this timbering five drifts were used. There were two superimposed drifts on either side, clearing a way for the posts, and there was also a crown drift. As soon as the posts were set, the ground between the upper post drift and the crown drift was stoped out and the arch segments set.

This method, of course, was very expensive in the use of timber, but it permitted the steam shovel to excavate the entire core of the tunnel, at this point about 51% of the total excavation. Except for the desirability of getting the steam shovel into rock as quickly as possible, very much lighter timbering and bracing would have been used. The essential purpose of the whole method was to allow the steam shovel to go through and reach rock as quickly as possible.

One peculiarity about this section, which caused some concern, was the problem of how to support the roof load

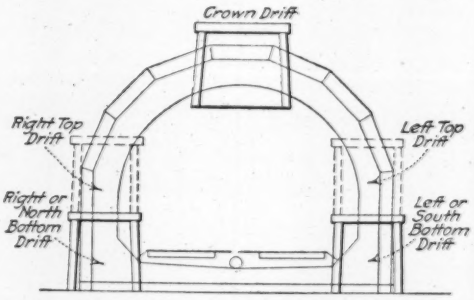


FIG. 6. SEVEN-SEGMENT TIMBERING IN WEST END; TIMBERS SET SOLID AND USUALLY DOUBLED

until a concrete base could be put in. The top load was so heavy that even 12x16-in. timbers set solid would not carry the burden without crushing. These timbers were doubled, two sets of posts as well as two sets of arch timbers being used.

The posts rested on mud sills no wider than the post, and strange to say, no settlement took place, in spite of the fact that the ground was very soft when disturbed. The ground when worked up by the steam shovel would get so soft that the shovel would have buried itself if not carried on a solid floor of timbers. The explanation is, of course, that when the water was drained off the ground became very hard, and that the roof timbers acted as a perfect arch, carrying the load to the surrounding ground by arch action instead of transmitting it to the posts.

The original intention was to put in a solid floor of concrete, as shown in Fig. 6, but finally only a strut 18 in. wide every 30 ft. was used.

*Chief Engineer, Canadian Pacific Ry., Winnipeg, Man., Can.

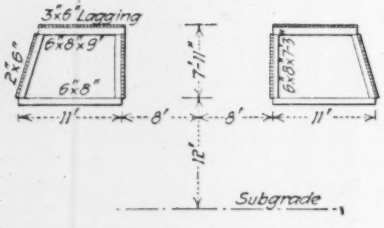


Fig. 1. Two Wall-Plate Drifts

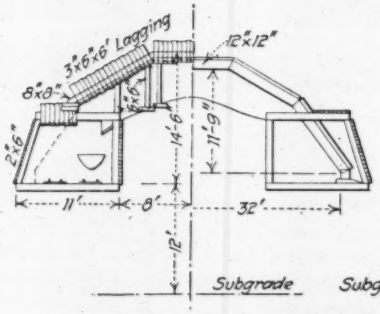


Fig. 2. Stoping Out Between Drifts

Fig. 3. Placing Five-Segment Timbering

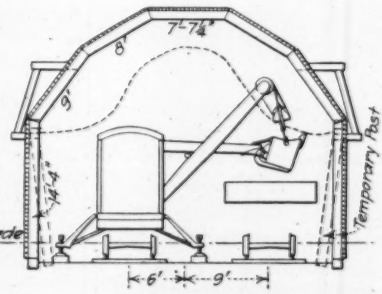


Fig. 4. Excavating Core

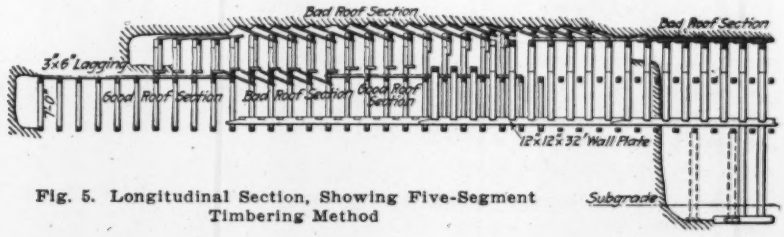


Fig. 5. Longitudinal Section, Showing Five-Segment Timbering Method

FIGS. 1 TO 5. FIVE-SEGMENT TIMBERING IN EAST END, ROGERS PASS TUNNEL

How the work in the rock section was planned to give maximum steam-shovel excavation has already been described (*Engineering News*, Feb. 24, 1916, p. 382). As there stated, the method was chosen for economy of construction cost. That this worked out in practice is shown by the following figures:

If the ratio of overbreak will continue the same as it has in the past, the total excavation in the tunnel proper will be 710,000 cu.yd., omitting quantities in the pioneer tunnel and the crosscuts. The quantities handled by hand will amount to 110,000 cu.yd., or about 15½% of the total, the remainder, or 84½%, being handled by steam shovel.

Steel Dam Eighteen Years Old Still Well Preserved

In the last part of the last century there were signs of the development of a new type of dam—the steel frame with steel plates as a water-retaining surface. Several such dams were built and gave promise of successful use, but for one reason or another they have not been followed by any others. One pronounced objection to the type was the great possibility of corrosion. It seemed probable that the constant wetting to which the dam is subjected would hasten its rusting and early failure. It is very interesting, therefore, to record the condition of such a dam built over 18 yr. ago, and still in successful use.

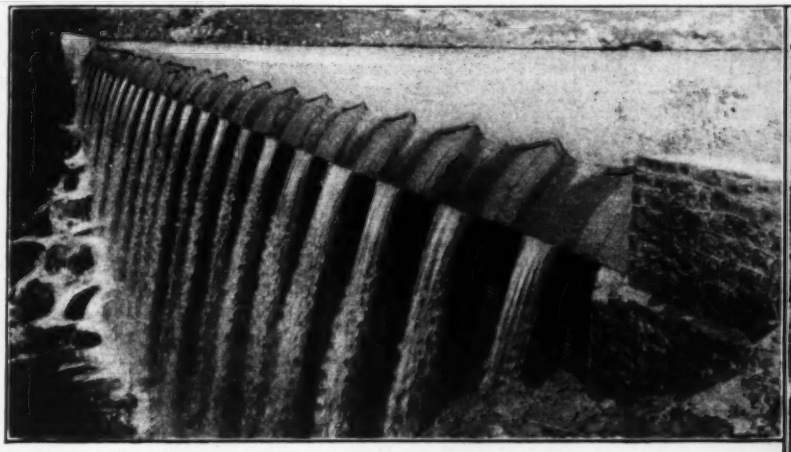


FIG. 1. VIEW TAKEN MAR. 25, 1916, OF THE 18-YR.-OLD STEEL DAM AT ASH FORK, ARIZ.

FIG. 2. LOOKING ALONG THE CREST OF THE ASH FORK DAM

The Ash Fork dam, situated four miles east of Ash Fork, a station on the Santa Fe Ry., is a steel dam built across Johnson's Cañon in 1898, to store water for the locomotives of the railway. It was described, with a large inset sheet, in *Engineering News*, May 12, 1898, p. 299. The dam is 184 ft. long on top and about 300 ft. in total length. Its greatest height is 46 ft. It consists of a series of vertical steel frames of A-section, footing on concrete bedplates on rock, with an upstream inclined face of steel plates spanning the bents. As shown in Fig. 1, the vertical downstream side of the frames is covered with corrugated iron.

The original coating consisted of two applications of dry red lead and boiled linseed oil. Since then (1898) the dam has been painted but twice, each time with a single coating of Dixon graphite. It is carefully watched for any signs of corrosion and has been painted as frequently as necessary in the judgment of the general foreman of bridges and buildings, who has been on this division (Albuquerque) since the dam was built.

The steel dam is the lowest of a series of four dams in a small cañon, or gully. None of the others is steel. Two are masonry and the latest one (1906) is a curved concrete structure.

There is no reason, judging from the present condition of the steel dam, why this should not have been of the same design so far as permanency goes. The steel dam is in practically as good condition today as when erected.

The general foreman of bridges and buildings, V. C. Proctor, says that except for a few scattered pittings there are no evidences of corrosion except in the bottom plates, which are in contact with the mud of the reservoir.

At the time the dam was inspected by one of the editors (Mar. 25), water was flowing over the crest, but this occurs only at intervals, for the water comes almost wholly from melting mountain snows and summer showers and at times the stream is nearly dry. The object of the four reservoirs is to catch and hold as much of this spring run-off as possible.

The face of the dam is water-tight so far as a casual inspection showed. The corrugated plates on the downstream side keep out the spray of the overflow, yet the condensation of moisture in the cold interior apparently keeps the trusses and steelwork continually damp so long as there is water behind the dam.

The base of the structure can be readily exposed and painted without interference with the water-supply, for the water-mains connect with an intake in the dam above, permitting the steel dam to be bypassed.

Public Water-Works Financing

By W. L. Butcher*

From the point of view of engineers cognizant of the physical life and the rate of depreciation of water-works property there exists a considerable inequity in the usual method of financing by means of bond issues running for a moderate term of years.

It is conceived that in the ideal case the life of the bonds should run to the life of the property and that the amount paid off in the later years, when the population and number of consumers is greater, should be larger than in the early years, to the end that the burden should be equally distributed among the benefactors of the utility.

At this point, however, particularly in the case of very long lived structures, such as many of the component parts of a water-works property, conscientious public officials having in mind the financial and economic phases of the matter step in and say that it is not good public policy to postpone for a long period the repayment of bond issues. They view with alarm the rapid growth of debt of communities and consider that, within reason, laws should be so framed that bonds may be paid off as rapidly as possible.

For private properties such a policy may be a sound financial one as in a broad sense it makes little difference to the owners whether earnings are paid in dividends or put back in the property. This policy may also hold to a certain extent in case of special assessments where the whole cost is directly assessed on abutting property and where the value thereof may assume to be immediately increased to the extent of the assessment. With public water-works, however, where large numbers of consumers have no direct or indirect interest in the works and where even the "real" property owners have a very intangible interest, the inequity exists, however much sound "public policy" may insist on the prompt payment of debts.

The attention of water-works officials has been particularly called to some phases of this matter by a recent paper before the New England Water-Works Association on "Municipal Water-Works Financing in Massachusetts as Affected by Recent Legislation."[1]

Massachusetts Water-Works Financing

Under Massachusetts laws bonds for the construction of new water-works must not run longer than 30 years, they must be serial bonds and the payments in any one year must not be less than in any subsequent year. This latter feature has been changed, owing largely to the efforts of the authors of the above paper, so that the first payment on the serial bonds for new works may be postponed for three years.

Briefly the law and engineering exigencies in this particular instance take about the following attitude:

1. If you wish to construct a water-works the life of the bonds, which is supposed to be of such length as to distribute the burden equitably, shall not be more than 30 years, in spite of the fact that many parts of the structure, after taking into account all the possibilities of physical and functional depreciation, will have a life of 60 or 75 or even 100 years.

2. On account of the engineering exigencies of the case it will be necessary for you to build and commence to pay for works planned, in part, for a population which will only be in existence 30 or 40 years hence.

3. While you should be perfectly ready to build partly for the future, in view of the practical difficulty of doing otherwise, we will further ask you to pay not only an equitable portion based on the probable use of the works today and in the future, but more in the early years than the future generation will pay in the thirtieth year when the population for whom you have magnanimously built these works and over whom the charge will be distributed may be twice as large as today and when interest charges owing to previous payments on the principal will be almost nothing.

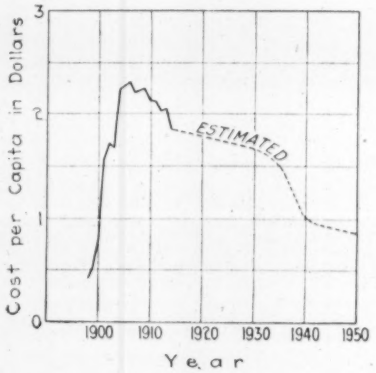


Fig. 1

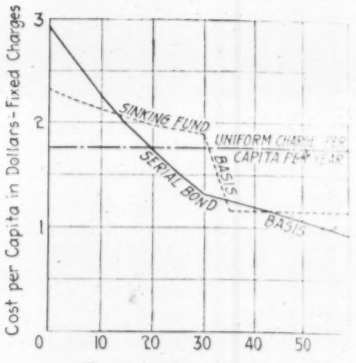


Fig. 2

FIGS. 1 AND 2. COST PER CAPITA PER YEAR, MASSACHUSETTS METROPOLITAN WATER-WORKS

Fig. 1 shows cost per capita per year, including interest, sinking fund and maintenance charges. Fig. 2 shows comparison of charges during 60 years for plant financed by 30-year sinking-fund bonds, 30-year serial bonds and by an approximately uniform charge based on probable population. Works at end of 60 years have same value due to distribution works built during last 30 years

Case of Metropolitan Water-Works

The discussion may be illustrated by the case of the Massachusetts Metropolitan Water-Works, which provides a very good example on account of the probable long life of an exceptionally large proportion of the works. Most of the bonds issued for this work, however, run for 40 years and are of the sinking-fund variety so that conditions are somewhat ameliorated from what would have been the case if the law cited above were in effect.

The original act of 1895 provided that no sums should be assessed on the District until 1898, that $300,000 should be assessed in that year and that an additional $200,000, as well as certain minor adjustments, should be assessed in each subsequent year until the entire amount required was reached and thereafter the annual requirements for interest, sinking fund and maintenance should be collected each year.

In the early years, however, this provision did not furnish sufficient money for operation and such expenses were taken from the loan fund.

*With Metcalf & Eddy, Consulting Engineers, 14 Beacon St., Boston, Mass.

[1]Read before New England Water-Works Association, Jan. 15, 1916.

This situation existed until June 30, 1901, when by a change in the act the whole amount necessary was to be assessed each year. In the first year under the new method, sufficient to repay to the loan-fund money which had been taken therefrom for operation was collected. Thereafter by assessments and premiums the sinking fund increased by leaps and bounds, until in December, 1914, it amounted to $11,533,453, an amount which required additions of only about $250,000 annually to extinguish at maturity the whole debt then outstanding, and at a time far in advance of the expiration of the life of much of the property.

Recognition of the rapid growth of the sinking fund led in 1914 to a reduction in the contribution thereto to $280,333, whereas in some of the earlier years the contribution had amounted to over $800,000 per annum. It is assumed that as far as the original debts are concerned the annual sinking-fund contribution will approximate the former amount from now on.

COST PER CAPITA FOR WATER IN THE MASSACHUSETTS METROPOLITAN WATER DISTRICT

Year	Estimated Population	Charges for All Purposes	Cost per Capita
1898	815,000	$335,800	$0.41
1899	835,000	428,400	.51
1900	856,000	695,700	.81
1901	874,000	1,369,900	1.57
1902	892,000	1,523,600	1.71
1903	910,000	1,536,400	1.69
1904	928,000	2,080,700	2.24
1905	946,000	2,157,800	2.28
1906	972,000	2,243,200	2.31
1907	998,000	2,188,300	2.20
1908	1,024,000	2,271,200	2.22
1909	1,050,000	2,360,700	2.25
1910	1,077,000	2,297,800	2.13
1911	1,101,000	2,333,000	2.12
1912	1,126,000	2,289,500	2.03
1913	1,151,000	2,364,600	2.05
1914	1,176,000	2,173,000	1.85
1940*	2,100,000	2,100,000	1.00

*Estimated.

The estimated population and the amount of money contributed each year by the district and the per capita amounts are shown in the accompanying table. Conditions in the future are of course problematical, but we will assume that in 1940, when all of the bonds for construction of the earlier works have been retired, that the entire present distribution system must be replaced, that the amount of new construction to keep pace with the increased population averages about as at present and that it is necessary to go to new sources of supply at costs already estimated by the Water Board. It seems unlikely that the people of that time will be paying charges on over $25,000,000 worth of bonds and probable that they will be paying on very much less. The charges on this amount, including operation, would approximate $1 per capita of the population of that date.

The fluctuations which the charges per capita have undergone are graphically shown in Fig. 1, and indicate that whereas in the early years a charge of about $0.50 per capita was made and in the future a charge of probably less than $1 per capita will be required; during many of the years the population of the district has contributed at a rate of over $2 per capita.

The inequalities of both the ordinary sinking-fund and the serial-bond method, particularly the latter, are shown by Fig. 2, which gives the results of a computation unnecessary to repeat here, based on a hypothetical case, which assumes a community of 25,000 that increases 2,500 every five years, that the cost of the original works is $1,000,000; one half having a life of 60 years and one half 30 years, and that distribution works are increased by an expenditure of $50,000 each five years.

All of this points to the desirability of the engineer coöperating with officials handling the finances to procure a less unbalanced method of procedure. On its face the sinking-fund method appears less inequitable than the serial-bond method, although best modern financial thought looks with disfavor on this method on account of the danger, unwieldy size and consequent labor involved in administration of those large accumulations.

It is perhaps not possible to lay down any hard and fast rules, but it is perfectly evident that from an engineering and mathematical standpoint it is a simple matter to so compute the annual payments as to distribute the charges in an equitable manner. It remains only to modify the results to such an extent as may be dictated by financial and economic considerations.

It might also be added that these remarks apply with particular force to works of considerable magnitude where from the very nature of the case a long view into the future must be taken at the time of the original design.

Prehistoric Irrigation Ditch Built by Indians

Apropos of the description in *Engineering News* of Feb. 17, 1916, of what is probably the oldest masonry dam in the United States, it is worth noting that the Spaniards were not the original irrigation promoters in the Far West. There exist in several parts of Arizona the remains of irrigation systems that date back to prehistoric days, when some quite highly civilized Indian tribes inhabited these valleys.

One of the most famous of these ancient irrigation works is on the Arizona state highway from Prescott to the Grand Cañon. Water was taken from what is known as Montezuma's Well, a curious natural well 440 ft. in diameter and 93 ft. deep except in one spot where no bottom was reached at 500 ft.

One of the original ditches is shown in the illustration. The water carries a great deal of lime in solution,

ARIZONA IRRIGATION DITCH BUILT BY PREHISTORIC INDIANS

and the sides of the ditch have been preserved by the petrification of the original earth. One rancher at the present time is using several thousand feet of the old ditches, after merely cleaning them out. F. R. Goodman, state highway division engineer, was once tempted by curiosity to run a line of levels along the bottom of one of these old Indian ditches. He found the grade to be almost perfectly uniform at a rate of 0.01 ft. per 100 ft.

Pumping from Deep Wells Into Water Mains at Memphis

SYNOPSIS—Water from deep artesian wells is raised by screw-propeller pumps and forced by a centrifugal pump on the same shaft directly into the mains at Memphis, Tenn. Fifteen wells covering a distance of some 10 mi. are operated in this way, furnishing a supplementary supply to that from the old artesian-well plant, where 60 wells driven in a district a quarter of a mile square deliver water to a central pumping station. By the new system, wells are spaced so far apart that the draft from one well does not affect the flow of underground water to another well.

The City of Memphis, Tenn., is the largest city in the United States (and, so far as is known, in the world) that takes its public water-supply from artesian wells. Underlying Memphis at a depth of 300 to 400 ft. is a stratum of water-bearing sand some 800 ft. in thickness. This stratum, known geologically as the La Grange sands, rises to the surface many miles to the north and east of Memphis and exposes a large area to infiltration. This deep water-bearing sand is the chief reliance for pure water-supply over a large area of Tennessee, Arkansas and Mississippi.

At Memphis this water-bearing sand is overlain by a stratum of hard, impervious clay 150 ft. or more in thickness, as well as softer clays and sands. It is easy and inexpensive, therefore, to sink wells to this water-bearing sand; and the clay stratum around the casing of these wells prevents any percolation of water from higher levels. The water from these wells is pure and cool. Tests show practically no bacteria, and the percentage of mineral matter is very low for an underground water.

The original deep-well plant for public water-supply in Memphis was built for the Artesian Water Co. by the late Thomas J. Whitman, of St. Louis. The first wells were added to year after year as consumption increased, and the works were finally purchased by the city in 1903. Before water was drawn from this underground stratum the water in the wells would rise nearly or quite to the surface. As the draft in the wells increased, however, and especially as a number of wells were sunk within a short distance of each other, the level of the water in the wells fell 40 to 70 ft.

The water from these wells was collected as follows: A 5-ft. tunnel lined with brick was driven in a stiff clay stratum from the main suction well at the pumping station through the district in which the wells were located. From this main tunnel branch tunnels were run with wooden-lined drifts 30 in. high and 40 in. wide to the individual wells. These drifts were 80 to 90 ft. below the ground surface, and the water from the wells flowed by gravity through the drifts to the tunnel and then to the pump well.

The principal difficulty experienced in the operation of this system was the steady deterioration or falling off in yield from the wells. An extended investigation and report on this deterioration was made in 1902 by a commission of engineers and was published in *Engineering News* of Sept. 25, 1902. At that time 104 wells had been sunk by the company, and the first 42 of these had been abandoned after about 10 years' service. The falling off in yield was due partly to a gradual clogging of the sand surrounding the well. At the bottom of the well casing is placed a "Cook" well strainer about 50 ft. long, a cylinder of brass pierced with very fine slots 0.01 in. in width. It has been found that after a well has been a long time in service a peculiar incrustation builds up on the outside of this strainer and shuts off the flow of water. The cause of this incrustation is not fully determined. Various methods have been adopted from time to time for cleaning the strainers. One method is forcing water down the well to induce a reverse flow through the strainer. The most common practice, however, is to pull the casing out of the well and clean it—a rather expensive job.

The most serious situation in connection with the Memphis wells, however, was the limitation in the amount of water available in the territory reached by the tunnel system. The report of the engineering commission referred to stated that the area covered by the well system then in existence was only about one-quarter of a square mile. The commission stated that no matter how many additional wells might be sunk in this territory the amount of water economically available from it would not be much increased. The commission foresaw that the growth in population and demand for water would eventually require a duplication of the group of wells, tunnel system, pumping plant, etc., in some other district some miles away, where it would not interfere with the supply of water to the old wells.

It was evident that such duplication of the whole water-collecting and pumping plant would require a large outlay, and a further obstacle to its establishment was that the stratum of impervious clay in which the first collecting tunnel is driven is not found at the right depth in other parts of the city.

As soon as the city took over the works in 1903, experiments were undertaken having in view the pumping of water from individual wells directly into the mains, and a pump suitable for such work was designed by the late Thomas T. Johnston, of Chicago, at that time consulting engineer of the Memphis works. This pump proved unsatisfactory, however, and the increasing demand for water made it necessary in 1906 to install air lifts in three wells in the southern part of the city to supplement their flow. A difficulty in the use of the air lift at Memphis, however, is that the water contains a very small percentage of iron, which remains in solution when the water is first drawn from the well, but is precipitated when the water is exposed to the air.

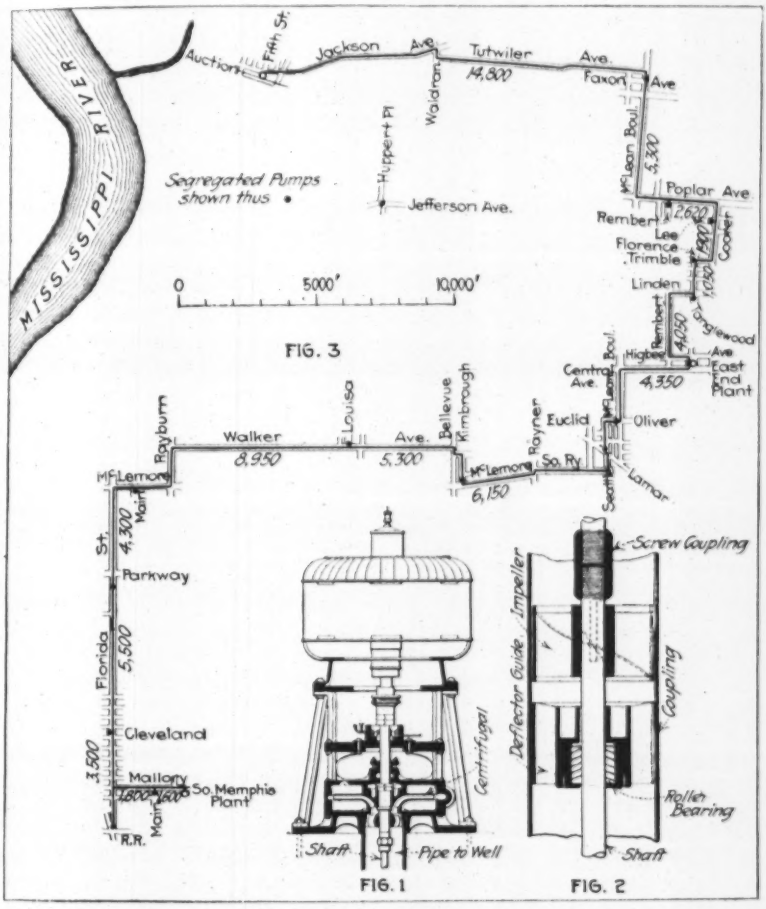
Experiments with apparatus for pumping directly from the wells were continued, and in 1910 a well was equipped with a pump designed by Wirt J. Wills, superintendent of the Memphis water-works. In 1911 four additional wells were drilled and equipped with this pump; seven additional wells were added in 1912, and three in 1913. Fifteen wells in all are now equipped with pumps of this design; and instead of being grouped in a small

area, as are the old wells, the new wells are scattered along an irregular line for a distance of about 10 mi., as shown in Fig. 3. The distance apart of these wells varies from 1,000 ft. to over 6,000 ft. With wells located so far apart, the draft of one well has no appreciable effect upon the flow of water to other wells. Each of these wells is capable of a yield of about 1,000,000 gal. per day.

Each of them is equipped with a motor-driven centrifugal pump on a vertical shaft that extends down the well and carries a series of screw propellers. Between the screw propellers are roller bearings for the shaft and guide vanes that arrest the whirling motion of the water due to the rotation of the propellers. The shaft carrying these screw propellers is made up in 4-ft. sections joined by screw couplings. The guide vanes are secured in a tube, which is also made up in 4-ft. sections. The whole apparatus is built up section by section and lowered down the well casing until the lowest section is below the normal level of water in the well, when flowing at its maximum rate.

The electric motor is a constant-speed induction motor developing 100 hp. at 850 r.p.m. The centrifugal pump has a 28-in. impeller and can deliver water at a pressure of about 60 lb. per sq.in. The motor and pump are placed in a concrete chamber underground and are reached through a manhole on the street surface. The motor is thoroughly protected by automatic appliances that, in case of overheating of the coils or the bearings, cut off the current supply and stop operations. Two men on motorcycles—one for the night shift and one for the day shift—make the rounds of these 15 pumps regularly and attend to lubrication, etc. A venturi meter is placed on the delivery main from each well, so that its output is recorded. It is claimed that in a test recently made of one of these pumping units a total efficiency of 50% was attained for the combined motor and pump equipment.

It will be evident that with this system of individual pumping units ideal conditions of pressure distribution are attained, and a minimum expense is required for street-main construction. Each well supplies normally the demand from the district immediately around it, but the mains being all connected in one general system the surplus delivered in any district where the consumption may fall below the delivery will be delivered to other districts. It would be apparent also that the centrifugal pump, which increases its output as the head drops, is admirably suited for use with this system. Details of the pumping machinery are shown in Figs. 1 and 2.



✚FIGS. 1 TO 3. DETAILS OF DEEP-WELL SYSTEM AT MEMPHIS

Fig. 1—Elevation of electric motor and centrifugal pump at top of well. Fig. 2—Vertical section through screw-propeller pumping system for deep wells designed by Wirt J. Wills. Fig. 3—Sketch map, showing location of individual deep wells for water-supply of Memphis

Mr. Wills applied for a patent on this system of pumping on May 23, 1910. There were long delays and interference proceedings in the Patent Office, however, and the patent was not issued to Mr. Wills until Mar. 14, 1916. Its number is 1,175,856. The patent contains exceedingly broad claims. One of them, for example, reads as follows:

> A fluid-pumping mechanism, consisting of a screw-propeller lifting member capable of raising the water from below the point of suction lift, and a centrifugal pumping element of the same capacity as the lifting member, and arranged in position to receive the discharge from the lifting element and a motor connected with said lifting and pumping elements.

Whether Mr. Wills can sustain his claim to being the pioneer in developing this system of pumping from deep wells directly into the mains remains to be seen. Readers who are interested will find a valuable paper on "Methods of Deep-Well Pumping," by C. B. Burdick, of Chicago, read June 5, 1907, before the Western Society of Engineers and published in *Engineering News* of July 18, 1907, p. 54. In that paper Mr. Burdick referred to some early work in the design of deep-well vertical-shaft centrifugal pumps done by John W. Alvord in 1902, Prof. D. W. Mead, of the University of Wisconsin, Byron Jackson, of San Francisco, and P. J. Wood, of Los Angeles, Calif. The American Well Works, of Aurora, Ill., has also been active in this field.

Whatever the final adjudication as to patent rights on the system may be, the work at Memphis is of great interest, as it is doubtless the largest installation ever

made on a city water-supply of pumping from individual wells directly into the mains.

Especially noteworthy at Memphis is the satisfaction which this system gives to the water consumers. In the long and intensely hot summer, water distributed through street mains in Memphis from the old well system becomes very warm, and on exposure to the air in its passage through the drifts, collecting tunnels, pump wells, etc., some iron is deposited. The water from the independent wells, on the other hand, comes from the ground at a temperature of about 55° and passes so quickly to the consumer that little heat is imparted to it and there is no chance for aëration and deposits of iron. It is difficult to convince the consumers in the districts supplied from these independent wells that they are not being supplied with water of superior quality from an entirely different source than the water supplied to parts of the city served from the old well system.

Erection of Old Trails Bridge Over Colorado River

By J. A. Sourwine*

SYNOPSIS—Long-span steel arch trusses built in horizontal position with end hinges in place, and one half-span overlapping the other at center. Half-spans, weighing 150 tons, then hoisted into position at center hinge by means of temporary central tower supported on pile bents and constructed from material later used in bridge floor system.

The "Old Trails" arch crosses the Colorado River on the route of the national "Old Trails Highway," at a point about 12 mi. below the town of Needles, San Bernardino County, Calif. The bridge consists of one main span—a three-hinged arch, of length 592 ft. c. to c. of end hinges and width 25 ft. c. to c. of trusses—and approaches, each consisting of two 56-ft. plate girders supported on steel towers. The main-span floor extends 8 ft. beyond end hinge to the approach girder. Thus the total length of bridge is 832 ft.

Certain unusual features in the design were made the basis by the contractors for a rather novel method of erection. The end hinges are of ordinary pin type. The center hinge is of ball-and-socket type, with spherical compression bearing. A steel casting with milled head and convex spherical bearing surface serves as the male portion of the center hinge. A cast-steel hood with cylindrical hole or pan, to receive a flat cylindrical nickel-steel compression piece, one face of which is a concave spherical surface which takes thrust from the male half while the other face distributes the stress to the hood, constitutes the female portion of main center hinge. Adjustment is provided in the shape of cylindrical steel shims of varying thickness, to be inserted in the pan of the hood, back of the nickel-steel compression piece.

Four auxiliary leaf hinges are provided, each consisting of four 3½x6-in. angles riveted to the sides of upper and lower chord, with 6-in. legs horizontal, and spaced to allow the insertion of a 6x½-in. steel plate which was inserted after the trusses were in place. These plates form leaf hinges flexible under rise and fall of arch, as caused by temperature changes, but acting as a tensile member against any tendency to separation at the leeward hinge under wind pressure.

Both the peculiar type of center hinge and the unusual natural features of the crossing were taken advantage of in planning the erection. At low water a sand bar extended out into the river from the Arizona side about 220 ft., from which point the silty temporary bottom of the river sloped gradually out to a depth of about 8 ft. below the surface of the water, thence more abruptly to 12 ft., and thence again gradually to a maximum of 30 ft. below the surface of the water, about 65 ft. from the California hinge.

Soundings taken during the preliminary survey showed rock to slope away rapidly on each side of the river to a depth of over 80 ft. below low water. The filled bottom of the river showed to be in most part silt and very fine sand. Some thin gravel strata were encountered at depths varying from 30 to 50 ft. At a depth of about 42 ft. one gravel stratum was reported as having a thickness of 1 to 2 ft.; this was recommended by the writer as the minimum depth for support of the erection falsework.

The engineer of the Kansas City Structural Steel Co. conceived the idea of driving piles out into the river as far as scour of current would allow and erecting the trusses in approximately horizontal position, with end hinges seated, and then raising them into position by a central temporary tower supported on pile bents, material from the bridge floor system to be used for the construction of this tower.

In accordance with this scheme the main abutments were first constructed, the end hinges set in place, the trusses on the Arizona side built out on a sand bar from that side, and continued to the center hinge on piling driven in shallow water to a distance of about 70 ft. beyond the end of the sand bar. The California end hinges were then set in place, and piling was driven from the Arizona bank to within approximately 60 ft. of the California hinges. The trusses on the California side were cantilevered out across the gap and then built up on the piling. Near the center hinge the two halves of the bridge overlapped, the California half lying on top of the Arizona trusses previously constructed, as shown in Fig. 3.

Vertical and diagonal members were riveted in place and all chord joints riveted up. The lateral struts and lateral diagonal rods were bolted loosely in position, so as to allow of some slight movement between the trusses during erection. Sufficient lateral bracing near the center hinge was left out to allow the half-spans to clear the erection tower, which was built in the clear width between trusses, as shown in the view in Fig. 4.

*Designing Engineer, "Old Trails Bridge," member of Sourwine & Mahoney, Consulting Engineers, San Bernardino, Calif.

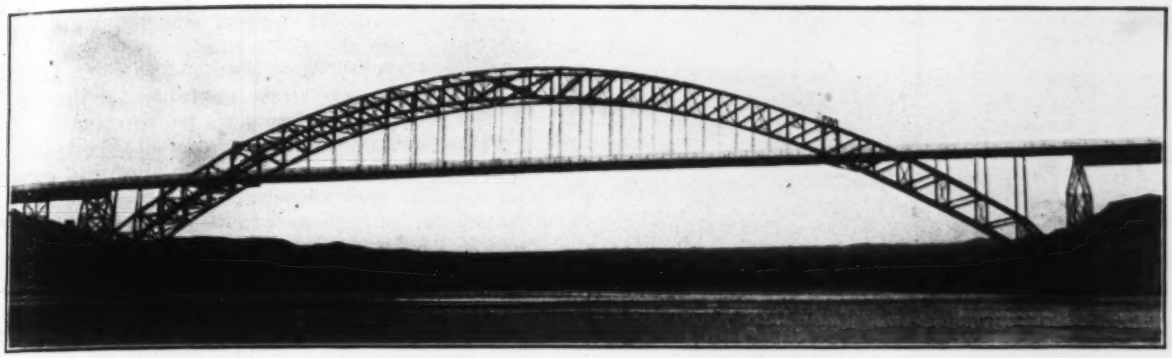


FIG. 1. THE "OLD TRAILS" ARCH OVER COLORADO RIVER; SPAN 592 FT. BETWEEN END HINGES

The erection tower was built up almost entirely of members taken from the bridge floor system. The columns were framed in the shop to the lengths desired for the tower and cut afterward to the lengths desired for use in the bridge.

The foundation consisted of 36 piles (9 at each corner) driven to an average penetration of 42 ft. and cut off 2 ft. above low water. This piling was capped with fir timbers; bridge floor stringers consisting of 12-in. I-beams were laid transversely across these timbers to aid in distributing the load on the piling, and 24-in. I-beams, later used as bridge floor-beams, were laid transversely across the top of the distributing beams, to serve as supports to which were bolted the columns of the tower. The columns were constructed from sections of the wind chord of the bridge. The horizontal bracing of the tower consisted of 24-in. I-beams longitudinally and 12-in. I-beams transversely, the sway bracing of single 3½x3½-in. angles with special bent-plate connections. Bolted connections were used throughout.

Three 20-in. 65-lb. I-beams were used on each side of the tower parallel to the bridge for loading beams. Each set of these beams rested on special cap plates on the columns, the beams of each set being bolted together with 8-in. channel separators. The raising beams, laid transversely across the top of the loading beams, consisted of four 24-in. 80-lb. I-beams, one pair on each end of the tower, each pair spaced 41½ ft. and bolted together with four 12-in. channel diaphragms. On top of the raising beams was placed a special connection for the top load block, two short lengths of 15-in. channel riveted together, with 2¾-in. separators between them. These channels were placed 2 ft. 9 in. on centers on each end of the raising beams, and fastened to the latter with ¾-in. machine bolts. The connection for each load block was two 4-in. pins through the webs of the 15-in. channels.

The two halves of the arch were hoisted successively, the California half first. Two sets of load blocks and cables and two 30-hp. hoisting engines were used—one for each truss of a half-span. A separate connection was made for the upstream and downstream trusses, which were hoisted independently and kept even by regulating the relative speed of the two hoisting engines. The load line, ⅝-in. wire rope, was reeved through the blocks so that both ends came out on the same side of the top block. These ends were brought to the foot of the tower and passed through gate blocks lashed to the piling, the two ends of each cable being then run out horizontally and attached to separate drums of the hoisting engine. The use of two drums on each hoisting engine made possible considerable economy in size of hoisting engines used, the load being hoisted about halfway on one drum and dogged, and the other drum then used to raise the load to the desired height.

Two sets of four 2½-in. bolts 20 ft. long, with threaded length of 6 ft. on each end, were also suspended from the channels used to support the load blocks, at the two corners of the tower nearest the California shore, for use as slings for supporting the end of the California trusses after raising. By the use of these bolt slings, the necessity of two extra sets of blocks was avoided, the Arizona half-span being raised with the two sets of blocks while the California trusses were in the slings.

Owing to the unusual method of truss erection and the lack of precedent for any work of similar magnitude, and also to the well-known undependable character and shifty nature of the Colorado River bottom and some consequent degree of uncertainty with regard to the stability of the tower foundation, it was thought best to exercise unusual caution in the work of raising the trusses. After all connections were completed ready for raising, the load block connections were made for the California trusses and the center-hinge end was raised about 2 ft. clear of its ground supports—the span then

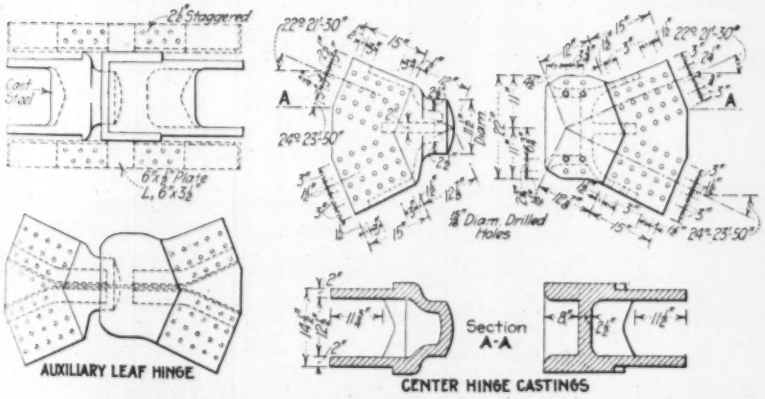


FIG. 2. CENTER-HINGE CASTINGS AND AUXILIARY LEAF HINGE

FIG. 3. THE HALF-ARCHES OF TRAILS BRIDGE ON FALSEWORK BEFORE RAISING

hanging with one point of support at the end hinge and the other at the pin connection, transferred by load blocks to the erection tower. As a preliminary test of the erection-tower foundations, the California trusses were left suspended over night in the position described. Observations of the base of tower showed a maximum shift of position of only 0.01 ft. elevation, at one corner of tower, during this 16-hr. suspension. This test was felt to be satisfactory evidence of the stability of tower foundations, and the work of erection was continued.

The California truss was raised first and was eased into the slings, with center-hinge end in position slightly above that previously determined by calculation as the proper height, to allow for clearance required in raising the other half-span. The load blocks were then shifted to the other side of the tower and used to raise the Arizona half-span. The actual raising time for the first half-span was 20 min., the elapsed time 45 min. The actual raising time for the second half was 17 min., the elapsed time 32 min. About six hours was required for easing the first half into the slings and transferring connections to the other half-span. The entire work of raising trusses was done in one day.

It had been hoped to complete the truss erection in one day, by easing away the trusses till the center hinge came into bearing, but several unexpected delays made this impossible, and the two half-spans were accordingly left standing over night, with the California trusses in the slings and the Arizona trusses suspended by the load blocks.

On the following day the center-hinge ends of the two half-spans were lowered alternately, using the blocks and lines for the one half-span and the slings for the other, until the center hinge came into proper bearing. The total time of lowering into position was about six hours. Cables and slings were then slacked off and the trusses allowed to assume their own full weight. The center plates of the auxiliary leaf hinge were riveted in place, and work was started on dismantling of the erection tower and construction of the bridge floor.

Credit must be given the bridge company for unusual care and good workmanship in both fabrication and erection of the truss members. Measurements were made under the writer's supervision immediately after the trusses had been lowered into final position and while they were under initial load (their own dead weight only) to determine how accurately the center hinge had come to position. The steel temperature was taken carefully and the measurements reduced to the design temperature of 90° F. The result showed the center hinge of the upstream truss to be 0.05 ft. high and the center hinge of the downstream truss 0.03 ft. high, or an average of 0.04 ft. high for both trusses at the center hinge. As to position, the trusses were found to be approximately $\frac{3}{8}$ in. upstream at center—about what was to be expected from the slight difference in height at upstream and downstream hinges.

The ratio between increment of vertical ordinate at center, for small rise or fall at center hinge, and the corresponding increment of long chord of half-span, for arch of 592-ft. span and 100-ft. rise, is 3.24 to 1. Using the maximum error in height of center hinge of 0.05 ft., as found, the long chord of the half-span would appear to check within $\frac{3}{16}$ in. of the design length. This is a most unusual fabrication record for such a length of span.

Observation of the behavior of the tower during the erection of the trusses, made by transit from a point 200 ft. upstream on a line nearly at right angles to bridge, showed a maximum variation of top of tower from true vertical to be about 3 in. The greatest movement occurred when the California truss was resting in the slings and the Arizona truss was between one-half

FIG. 4. CALIFORNIA HALF OF ARCH SUSPENDED IN STIRRUPS AT TRAILS BRIDGE

and two-thirds of the way up. At this period there was a definite uplift observable in the columns on the Arizona side of the tower, and it was thought necessary, as a precaution, to tie down the Arizona legs of tower. This done, the raising of the truss proceeded, and as it rose higher and the direction of pull due to load again approached the vertical, the deflection of the top of the tower grew less. When the second truss had been raised to the proper height, the tower had again assumed its correct vertical position.

Some bending and snapping due to reversal of stress was noticeable in the long diagonals on the sides

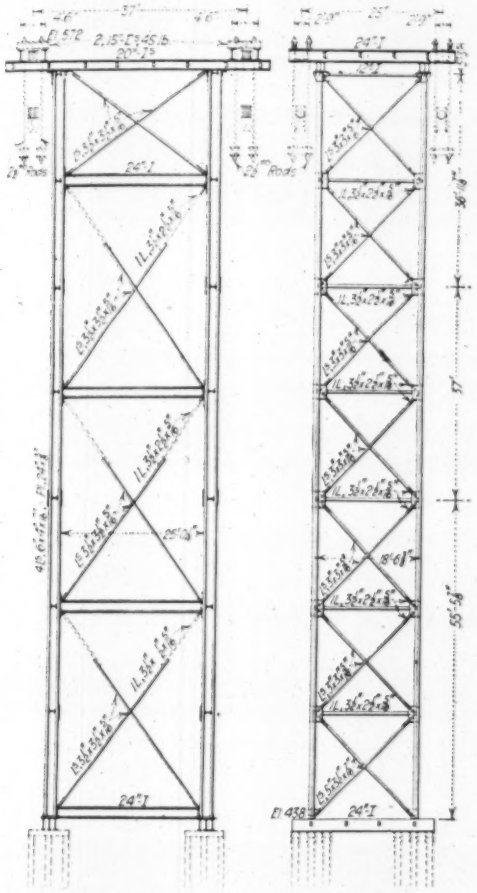


FIG. 5. SKETCH OF ERECTION TOWER
Steel shown in solid lines was part of bridge floor framing. Steel shown dotted fabricated for tower alone

of the tower during the raising, and there is no doubt in the mind of the writer that stronger and heavier diagonals should have been provided for proper factor of safety in erection design. An additional factor of safety could also have been provided by increasing the length of the tower parallel to the bridge. It should be borne in mind, however, that the intent of the bridge company was to build the tower entirely from material already on the ground for use in the bridge, and that the tower actually was so built with the exception of some splices of the diagonals, the short loading beams and some minor items in the way of connections.

Taking together the bold erection method, the accuracy of fabrication and the erection without accident, the work deserves unusual mention.

The bridge was built by the Kansas City Structural Steel Co., under Thomas McCurnin, Construction Superintendent. The contract was let through the United States Commissioner of Indian Affairs, June 30, 1915, and the structure was finally accepted Feb. 20, 1916. Design and superintendence were by the writer. J. P. Kemmerer acted as the writer's personal representative on the ground during construction and fulfilled the joint duties of inspector and construction engineer. The details of erection were worked out by A. M. Meyers, Architectural Engineer, Kansas City Structural Steel Co. The total contract price, excluding end wing walls, which were built by the respective counties on each side of the river, was $75,448. This amount does not include either cost of design or supervision of construction.

Legal Decisions of Interest to Engineers

Construction of Excavating Contracts—(Massachusetts). A contract requiring the contractor to excavate all "soil, earth and stones" does not oblige him to excavate a ledge of rock not known to him at the time he signed the contract. Where a contractor does work not within the scope of his contract, and the owner knows that the work is being done, assents thereto, and receives the benefits, although erroneously believing the work is covered by the contract, a court is warranted in finding that the contractor is entitled to recover for the work. (Howard vs. Howard, 112 N. E. 233.)

Construction Company Entitled to Lien—(Illinois). Under Illinois law relating to public improvements, it is not necessary that material furnished shall be entirely used in a public improvement to establish a lien against the money in the hands of a city due a construction company. The lien runs, not against the property or improvement, but against the fund in the hands of the city. The court in Alexander vs. City held that the construction company could recover for materials furnished a city though some of such material was not used on city work. (Alexander Co. vs. City , 111 N. E. 1017.)

Cannot Recover Cost of Making Tests—(New York). Where a contract for the equipping of a pier with machinery provided that, when the equipment was sufficiently completed to require the operation of the electric generating plant, the contractor should furnish a competent crew to operate the plant for a period of six days during which time proper tests should be made, the contractor could not recover from the city for coal and labor used in operating the plant to make the tests. (N. E. Const. Co. vs. City of New York, 112 N. E. 53.)

Surety Company Held Liable—(Kansas). Failure to comply with a provision in an indemnity bond issued by a surety company, which required the obligee to give written notice of the default within 10 days after learning of the fact, is no defense to an action on the bond, where it is neither claimed nor proved that the company suffered any loss or damage from the failure to give notice. Here a company failed to perform its construction contract. The plaintiff failed to notify the surety company of this within the stated 10 days and the surety company claimed a discharge from liability on the bond. The Kansas Supreme Court held the surety company not discharged from liability. (McClure vs. Freeborn Engineering Const. Co., 156 Pac. 692.)